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COMMENTS ON THE WHEAT SITUATION WITH SPECIAL REFERENCE TO THE OUTLOOK FOR SASKATCHEWAN PRODUCERS.‡

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During the past eighteen months or so, numerous articles and letters have appeared in the general Canadian Press, and the Farm Journals relating to the world wheat situation and its particular effects on Western agriculture. These articles and letters, in the majority of cases have either come from financiers, bankers and newspaper reporters of feature articles of the East, or from the more radical element of the farming population of the West. In the former case, the tone of the articles is sometimes lacking in sympathy with Western Canada, and the writers of the articles have frequently shown themselves to be quite unfamiliar with Western conditions. On the other hand, many of the Western writers, whose knowledge, experience, and training have been limited to their agricultural operations are generally extremely pessimistic as to the future.

It is the opinion of many authorities that the situation is rather more serious than is realized by the financial interests of Eastern Canada and that prosperity for Western Canada is a long way from being, "Just around the corner." On the other hand, they hold the opinion that many of the leaders of farm thought in Western Canada are unduly pessimistic. With these thoughts in mind the following article has been prepared, in the hope that a little more light might be thrown on what has been taking place within recent years with respect to wheat production and prices, and also on what might be expected to happen in the future.

It was decided to treat the study from two standpoints, (1) the sources of the increases in acreages and production since the war, and (2) the relationship between wheat prices and all wholesale prices.

In order to bring out the relative importance of increases in wheat acreage, total production, and yield per acre the data available for use in this study have been tabulated into the following groups, (1) the principal wheat exporting countries of North America and the Southern Hemisphere, (2) the principal wheat exporting countries of Europe, (excluding Russia,) and (3) the principal wheat importing countries of Europe.

Reasonable forecasts can only be made after studying similar data of earlier occurrence. In making any forecast of the probable future trend of wheat prices, which is of vital interest to all people in Canada, a careful study

‡ A paper read to the Canadian Society of Agricultural Economics at their annual meeting with the Ontario Agricultural College, Guelph, June, 1931.

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† This paper replaces, in order of publication, a paper by Dr. Allen received in December 1930.

of past price relationships is necessary. The price of wheat in Canada has been compared with the wholesale index of all commodities since 1890. It has been found that there is a very close relationship between these two when examined from the long time standpoint. It is largely on the basis of this relationship which has existed for 40 years, that all remarks in the nature of a forecast are made.

Sources of Data and Methods

The statistics of acreage and production were taken from the annual reports of the United States Department of Agriculture and the Canada Year Books. The acreage and production data were tabulated under four general headings: (1) European Exporting Countries, (Rumania, Bulgaria, Hungary, Czechoslovakia, Yugoslavia); (2) European Importing Countries, (United Kingdom, France, Germany, Spain, Italy, Netherlands, Belgium, Denmark, Sweden, Austria,); (3) North Africa; and (4) Exporting Countries outside of Europe, (excluding North Africa and Russia); (United States, Canada, Australia, Argentine, and India.) It was found impossible to obtain reliable statistics prior to 1930 because of the changes in the boundaries of many of the Central European countries. Russian statistics were not included because of their unreliability in the earlier years.

The statistics on acreage and production as presented, total approximately 90 per cent of the total for the world, as reported in the Canada Year Book. These statistics show quite accurately the relative changes in world conditions.

All the trend lines calculated were linear or straight line trends. In each case 9 or 10 years were included, depending upon the relation of the changes between the first two years and the last two years. The tendency to exaggeration of trends was thus avoided.

It is recognized that 10 years is a comparatively short period on which to base a satisfactory trend line. However, in analysing the relative long time changes in prices and production, this statistical procedure is widely used, and at present 10 years is the longest post-war period available.

The data on the price of wheat at Fort William, for the period 1890 to 1909, were taken from the publication, "Wholesale Prices, Canada 1890-1909."* From 1910 to date, the wheat prices were taken from the publications of the Statistics Branch of the Saskatchewan Department of Agriculture, and "Prices and Price Indexes," published by the Dominion Bureau of Statistics.

The index number of wholesale prices used was the old index of 236 commodities (1913=100) published by the Dominion Bureau of Statistics. It was converted to a new base, 1910 to 1914=100, by multiplying each index number by 1.02. The price of wheat was converted to an index number on the same base, (1910-14=100), by dividing each monthly price of the series by the 1910-14 average for that month and then multiplying the result by 100.†

Purchasing power, as used here, is the price index of wheat multiplied by 100 and then divided by the wholesale index for the same month. Thus

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* A special report by R. H. Coats, Department of Labour, Ottawa, Canada, 1910.

† The 1910-14 twelve monthly averages, in cents per bushel, were:—Jan. 91: Feb. 92; March 93; April 94 May 96; June 97; July 98; Aug. 1.00; Sept. 1.01; Oct. 95; Nov. 95; Dec. 93.

purchasing power is merely the relationship between the wholesale price of wheat and the index of all wholesale prices. Assuming that price relationships were normal for the five pre-war years then a purchasing power for wheat of 100 would indicate that wheat prices were in a normal relationship with other prices.

Changes in Wheat Production

The World War disrupted the agricultural industry of Europe, particularly wheat production. The International Institute of Agriculture at Rome estimated that the world crop (including Russia) during the period 1914 to 1918 was 100 million bushels per year smaller than the crop for the last five pre-war years (*1*). The return to a relatively stable economic life would naturally tend to encourage those European countries which had suffered the most from war disturbances to attempt to re-establish their former production.

During the pre-war period, 1892 to 1913, the yearly increase in world wheat production, expressed as a percentage of the average for the 22 years, was 1.08 per cent, or 31 million bushels (*2*). This yearly increase was apparently sufficient for the estimated increase in world population of 1 per cent per annum.

The attempt of the world to recover from the cessation of increasing production during the war is amply illustrated in figure 1. The changes in world wheat production are characterized by an uneven upward trend since 1920. In 1923 and 1928 abnormally large crops were harvested. The yearly increase has been at the rate of 2.1 per cent of the average for the period, or at the rate of 65 million bushels per year.

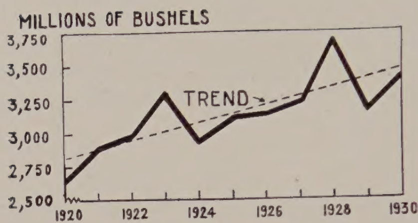
This annual increase of approximately 65 million bushels, although not based on the production of all the countries of the world (some minor countries besides Russia and China being excluded) is 5 million bushels per year more than the Canadian Wheat Pool estimates to be the necessary annual increase in production for the increasing world population (*3*).

That this yearly increase of 65 million bushels was a little more than the world could consume at prevailing prices is amply substantiated by the increase in the world carry-over since 1920, (table 1).

Table 1.—*Wheat carry-over or surplus, July 1920-1930.** (*Millions of Bushels.*)

	U. S. A.	Canada	Argentine	Australia	United Kingdom	Total
1920	139	24	40	16	83	302
1921	122	19	45	44	78	308
1922	116	42	59	12	61	290
1923	146	39	44	25	53	309
1924	145	60	55	23	62	345
1925	115	42	45	18	52	272
1926	99	55	50	15	53	272
1927	123	56	58	36	59	332
1928	128	114	78	38	60	418
1929	247	125	125	33	61	591
1930	275	136	40	45	44	540

* "The World Wheat Outlook and Facts that Farmers should consider." United States Bureau of Agricultural Economics, August 1930, page 13.



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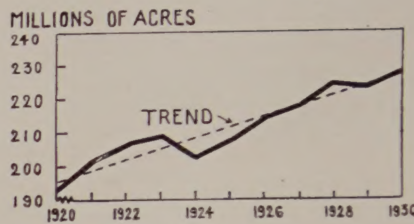

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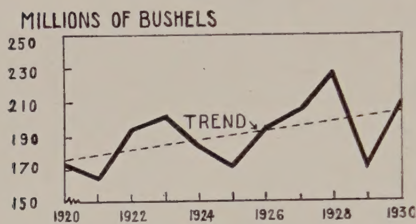

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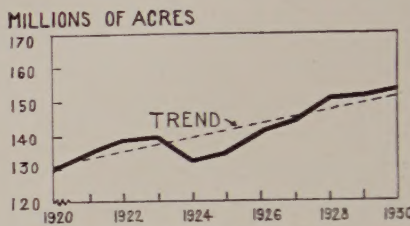

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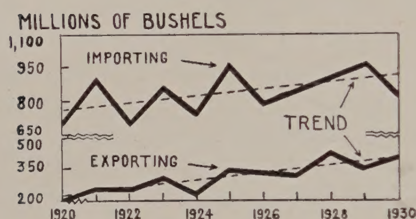

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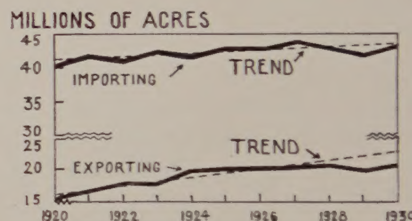

Figure 6.

Figure 1. Yearly Changes in the World Production of Wheat, (Excluding Russia and China). 1920-1930.

Production tended to increase at the rate of 2.1 per cent per year of the yearly average for the period, or 65 million bushels per year.

Figure 2. Yearly Changes in the Production of Wheat in the Exporting Countries outside of Europe, 1920-30.

Production tended to increase at the rate of 1.5 per cent per year of the yearly average for the period; or 29 million bushels per year.

Figure 3. Yearly Changes in the Production of Wheat in the Chief Importing Countries of Europe and in the Exporting Countries of Europe (excluding Russia).

Production in the importing countries of Europe has tended to increase at the rate of 1.7 per cent per year and in the exporting countries at the rate of 5.9 per cent per year of the yearly average for the period. In the case of the importing countries this amounts to 14 million bushels per year, and for the exporting countries 18 million bushels per year.

Figure 4. Yearly Changes in the World's Wheat Acreage 1920-1930.

The world wheat acreage has tended to increase at the rate of 1.5 per cent per year of the yearly average for the period, or 3.135,000 acres per year. This is a slower rate of increase than the world's wheat production.

Figure 5. Yearly Changes in the Acreage of Wheat in the Exporting Countries Outside of Europe. 1920-1930.

Wheat acreage has tended to increase at the rate of 1.4 per cent per year of the yearly average for the period, or 2 million acres per year.

Figure 6. Yearly Changes in the Acreage of Wheat in the Chief Importing and Exporting Countries of Europe, (Russia excluded) 1920-1930 .

The wheat acreage in the importing countries has increased very little, 0.5 per cent per year of the yearly average for the period, or 206,000 acres per year. The exporting countries of Europe increased their acreage at the rate of 3.5 per cent per year, or 600,000 acres per year. Most of this increase came between 1920 and 1925.

On the other hand it will be noticed that the world's carry-over was not altogether unreasonable until 1929. Undoubtedly the chief trouble has been the world record harvest of 1928, following a year in which the European yield was above normal.

Production of wheat in the exporting countries outside of Europe, during the period 1920 to 1930 increased at the average annual rate of 1.5 per cent of the average for the period, or at a rate of 29 million bushels per year, (figure 2). This was at a relatively slower rate than the importing countries of Europe, which increased their production 1.7 per cent per year of the average for the period, or 14 million bushels per year, (figure 3), and at a considerably slower rate than the exporting countries of Europe (Russia excluded) (figure 3), which increased their production at a rate of 5.9 per cent per year, or an average of 18 million bushels per year for the 10 year period.

Changes in Wheat Acreages

When we turn our attention to the increases in wheat acreage during this period we find that the rate of increase has generally been less than the rate of increase in production. The world acreage has tended to increase 1.5 per cent per year of the average for the period, or 3,135,000 acres per year, (figure 4). The acreage for the exporting countries outside of Europe increased at a rate of 1.4 per cent, 2 million acres per year, (figure 5). The acreage in the importing countries of Europe increased very slightly, the increase being only 0.5 per cent per year of the average for the period, or 206 thousand acres per year, (figure 6). The exporting countries of Europe increased their acreage 3.5 per cent per year of the yearly 10 year average, or 660 thousand acres per year, but most of this increase took place in the period 1920 to 1925, (figure 6). Since the year 1925 the acreage has been relatively stable.

It will be noticed that the deflation period of 1921 to 1923 did not greatly influence the acreage in wheat until 1924. In that year the acreage was reduced from 209 million acres in 1923 to 203 million acres in 1924, (figure 4). This cut of 6 million acres, was due almost entirely to the United States, in which country the acreage in wheat was reduced 10 million acres between 1922 and 1924. However, it took three years of low wheat prices to bring this drastic readjustment. During the same period the acreage of wheat in Canada declined from 23,260,000 in 1921 to 20,790,000 in 1925 (*4*).

The depression in wheat prices however did not materially reduce the acreages in the other wheat producing countries of the world.

Changes in Yield Per Acre

The production of wheat has been increasing at an annual rate of 2.1 per cent of the 10 year average for the past 10 years, but the acreage planted to wheat has only increased 1.5 per cent per year. It is therefore evident that there is an increase in production relatively greater than the increase in acreage, which indicates that yields per acre must be increasing. This is shown graphically in figure 7. The exporting countries outside of Europe have not tended to increase their yields. However, an increase in the yield of wheat is quite noticeable in Europe, and particularly in the exporting

countries of Europe. In figure 8, the calculated straight line trends for each of the three economic groups have been placed on the same scale. This was done by calling the first year trend value 100 in each case, and expressing values for other years as percentages of this first year. Under uniform conditions, one might say that the European exporting countries now tend to have a yield per acre about 28 per cent higher than in 1920, and the European importing countries 15 per cent higher. It seems safe to suggest that part of our wheat surplus problem has been due to this tendency on the part of Europe to increase yields per acre.

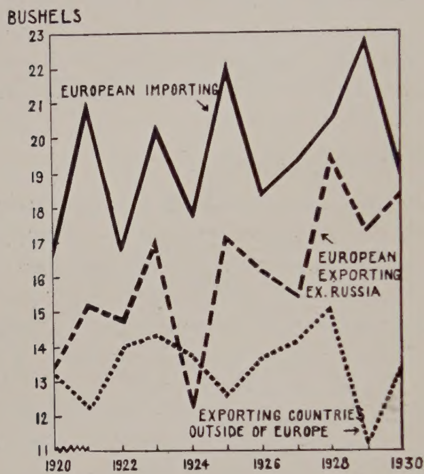

Figure 7.

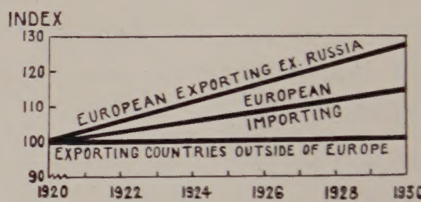

Figure 8.

Figure 7. Yearly Changes in the Yield per Acre of Wheat in the Chief Importing and Exporting Countries of Europe, (Russia excluded), and in the Exporting Countries Outside of Europe. 1920-1930.

The yield per acre in the exporting countries outside of Europe shows no trend. The yield per acre in the European countries shows a distinct upward trend. This is very noticeable in the case of the European exporting countries.

Figure 8. Trends in the Yield per acre of Wheat in the Chief Wheat Importing and Exporting Countries of Europe (Russia excluded), and in the Exporting Countries Outside of Europe.

Assuming uniform conditions, the exporting countries of Europe now tend to have a yield per acre 28 per cent greater, and the importing countries of Europe 15 per cent greater than in 1920. The Exporting countries outside of Europe tend to have the same yield per acre as in 1920.

Reports from Europe indicate that the increased yield of wheat is primarily due to the increased use of fertilizers, particularly of nitrates. Within recent years there has been an enormous increase in the production of synthetic nitrates in Europe. Since 1920, fertilizing materials have been cheap when compared with crop prices, as is indicated in table 2, but the drastic decline in agricultural prices during the last two years has changed this situation. It is possible that this unfavorable relationship will continue for a year or so, and thus tend to prevent further increases in yield due to increased use of fertilizers. Recent reports indicate that less fertilizer than usual was used in the Danube Basin in the fall sowing of 1930 (*5*).

TABLE 2.—*Changes in the prices of agricultural produce, feeding stuffs and fertilizers in England 1920-1930.** *(1911-1913 = 100).*

	Agricultural Produce	Feeding Stuffs	Fertilizers	Ratio of prices of fertilizers to agricultural produce.
1920	292	273	259	89
1921	219	181	220	100
1922	169	146	147	87
1923	157	136	123	78
1924	161	154	119	74
1925	159	152	114	72
1926	151	125	113	75
1927	144	139	110	76
1928	147	154	98	67
1929	144	139	100	69
1930	136	106	102	75

* Enfield, R. R.—Ministry of Agriculture, London, England, "The British Agricultural Depression," Proceedings of the Second International Conference of Agricultural Economists, Vol. 11, page 68.

WHEAT PRICES SINCE 1890

The wholesale price of wheat at Fort William, when converted to an index number on the same base as the Wholesale Index for all commodities, shows that the long time trend of the price of wheat since 1890, has corresponded very closely to the movement of the general price level, (figure 9). The long world-wide price decline which commenced about the period 1864 to 1868 with the beginning of the deflation of paper currencies, the demonitization of silver and a declining gold production, terminated about 1896 when the increases of gold, resulting from discoveries in South Africa in 1888, were producing their effects. Wheat, along with other commodities in the United States, declined irregularly from a high point of $3.00 per bushel in May 1867, to a low of 49 cents per bushel in January 1895 (*6*). This long decline of the general price level caused a severe and protracted agricultural depression. This was felt particularly by the wheat producers, as during this period there had been a rapid expansion of the wheat area of the American North West, coincident with the era of railway building.

The thirty-year price decline ended with a severe trade depression which lasted from about 1894 to 1896. Along with the prices of other raw commodities, wheat prices were carried to very low levels. At Winnipeg, the lowest average monthly price was reached in December 1895, when the price for No. 1 Northern was 55 cents per bushel. In the present depression the lowest average monthly price was 55½ cents per bushel, which was reached in December, 1930.

Due to the relatively rapid increase in the world's gold production, the general price level gradually worked higher until 1914. In 1896 the wholesale price index was 77, and in 1913 it stood at 102, (figure 9, 1910-1914=100). Wheat prices gradually rose with the general price level, sometimes rising a little more rapidly and at other times falling somewhat behind. This behaviour of wheat prices follows very closely the economic principle that the long-time price tends to equal the long-time cost of production.

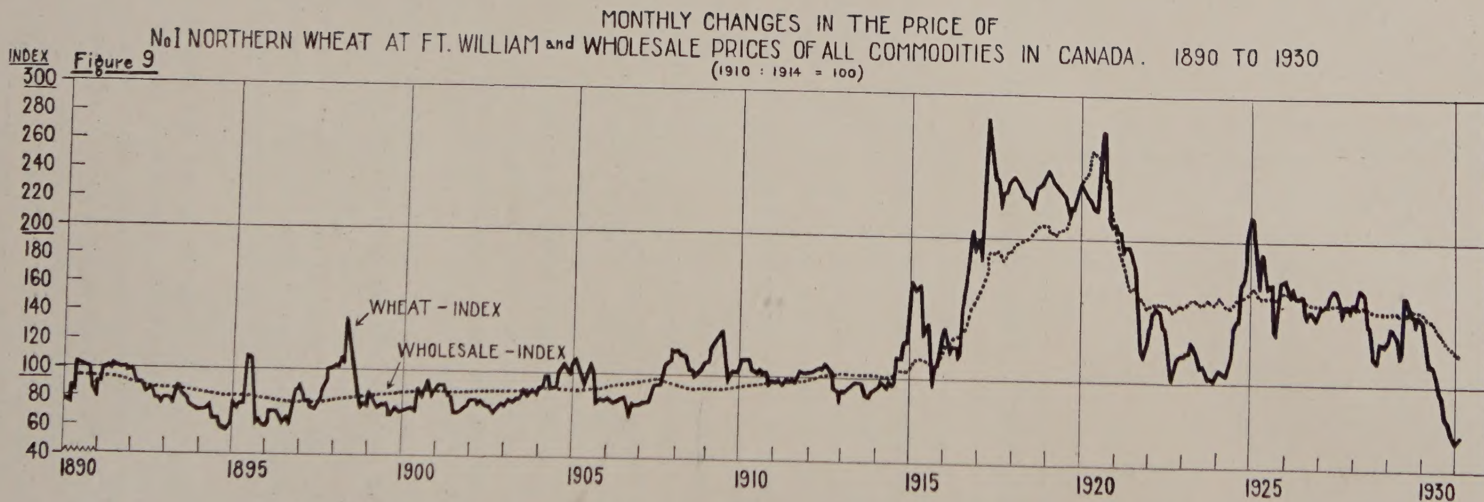

Figure 9. Monthly Changes in the Price of No. 1 Northern Wheat at Ft. William and Wholesale Prices of All Commodities in Canada. 1890 to 1930.

From 1896 to 1920 wholesale prices were rising. From 1920 to 1930 they have been falling. During all this period the index of the price of wheat has tended to fluctuate around the wholesale price index.

The inflation of currencies during the World War disturbed the normal price relationships, and for some years wheat prices were relatively higher than the general price level. Following the period of severe deflation the price of wheat was drastically below other prices for about three years. However, the relatively low price of wheat from 1921 to 1923, eventually caused reduction in acreages, as previously noted, and wheat prices again came into a normal relationship with wholesale prices. The regaining of the normal relationship of wheat prices to the general price level resulted not only from the reduced production, but also from the well known tendency of raw products prices to fluctuate more violently than other prices. This tendency has been noted by economists and statisticians for many years. At a time of depression and falling prices, the prices of raw commodities fall first and their decline is more pronounced. When prices cease to decline general conditions begin to improve. In the recovery phase of the cycle the most rapid and extensive upturns are in the prices of raw commodities. In other words, there appears to be more momentum to the prices of raw commodities, and the movements of these prices in either direction are the most difficult of all price movements to stop.

From late in 1924, until about the middle of 1929, wheat prices were in a relatively normal relationship with other wholesale prices. Since August 1929, wheat prices have been decidedly out of line with wholesale prices.

The purchasing power of wheat in terms of wholesale prices had a very slight tendency to rise from 1890 to 1918, (figure 10). The low point of the periods below normal, (100), appeared to be gradually becoming a little less pronounced. Since 1920 the reverse has held true. In the depression of 1894 the average monthly purchasing power of wheat reached a low of 69.2. The lowest monthly purchasing power of wheat in the depression of 1921 to 1924 was 66, which was reached in January 1924. In the recent depression the purchasing power of wheat reached a low of 48.5, which was the average figure for December 1930.

Except for a brief period about the middle of 1929, the purchasing power of wheat has been continuously below normal for two and a half years. The depression of 1921-24 carried the purchasing power of wheat below normal for three years.

There are many reasons for the recent drastic decline in wheat prices. Most of the discussions have centered around the so-called over-production. There certainly exists considerable over-production in relation to the present effective world demand for wheat. Probably one of the greatest single causes for low wheat prices, however, is a decline in the world price level. Wholesale prices are gradually returning to their pre-war relationship with the world's monetary gold stocks (*7*)*. This fact has scarcely received the

* 7 Warren, G. F. and Pearson, F. A.—"Farm Economics, Cornell University, N.Y., Feb. 1931, page 1443. "When the quantity of gold increased 3.1 per cent per year, prices were relatively stable............Prices show a very close relationship to the quantity of gold for 65 years before the War. Prices are rapidly returning to their previous ratio to gold."

Keynes, J. N.—"Monetary Reform," 1924, page 182. "If on the other hand, pre-war conventions about the use of gold in reserves and circulation were to be restored, which is, in my opinion, the much less probable alternative,—there might be, as Professor Cassel has predicted, a serious shortage of gold leading to progressive appreciation in its value." (i. e.—a fall in prices—authors' note.)

Lloyd, E. M. H.—Empire Marketing Board, "Farm Economics," Cornell University, N.Y., August 1930. "There is a general agreement that a fall in prices of things in general shows that money has not been increasing as fast as the production of goods. When there is a bountiful harvest and the price of wheat falls, we naturally say that it is due to the increased supply of wheat, but when there is a fall in prices over a wide range of commodities and the statistical position does not reveal any exceptional increase in production of each in relation to all the others, then the cause must be looked for in the monetary situation."

amount of attention that it warrants. Most of the leading economists and statisticians believe that little recovery can be expected in the general price level. In fact, the concensus of opinion seems to be that after a few years of comparatively stable prices there will be a further relatively serious drop to a still lower level. The remedy would appear to be international coöperation on monetary matters, which at present seems remote. The further lowering of the general price level however, does not necessarily signify that raw commodity prices will fail to recover their normal relationship with other prices.

Just what do these changing price relationships mean to the farmer of Western Canada? Based on the normal relationship between wholesale prices and wheat prices from 1910 to 1914, the normal price of wheat at Fort William gradually declined from a high point of $1.53 in January 1925 to $1.42 in December 1929, (figure 11). The average of wheat price quotations (unweighted) for this period was $1.49 per bushel, basis No. 1 Northern. It can be assumed that the farmers were able to obtain their costs of production during this period, if we believe in the theory of the long time cost of production tending to equal the long time price. The theory of long time cost of production tending to approximate long time price is strikingly illustrated by data on cost of production of wheat obtained from Farm Management Surveys in Saskatchewan, made in six representative districts from 1925 to 1929 and including over 800 farms (*8*). The average cost of production per bushel of wheat for the areas based on average provincial yields varied from $1.24 to $1.38. If we assume the average grade of wheat on the farms to be No. 2 Northern it would take approximately a price of $1.44 to $1.58 per bushel for No. 1 Northern at Fort William to equal the farm cost of production.*

After nineteen months of continuous decline from July 1920 to December 1921, the general price level flattened out from 1922 to 1929 on a new plane. If it be assumed that the general price level again flattens out at about the present position, (March 1931) which seems probable, after nineteen months of continuous decline, the normal price of wheat at Fort William should be approximately $1.14 per bushel.†‡

It is to be expected that wheat prices will eventually fluctuate around this level, sometimes a little above and sometimes a little below. The duration of this so-called normal price will depend upon how many years it will be before the price level takes another dip towards its pre-war relationship with the monetary stock of gold for the world.

It will be noticed that the estimated normal price for wheat of $1.14 per bushel assumes a general price level stabilized approximately at the present position. If the price level should rise materially in the next few years, due to a redistribution of the world's gold reserves, or international financial co-

* The wholesale index in January 1925 was 168.5 (1910-14 = 100). To have a purchasing power of 100 the price of wheat in index form would have to be 168.5. The average January price 1910-14 was 91 cents. Therefore the normal price for that month was 168.5 multiplied by 91 or $1.53. The December 1929 normal price was calculated in a similar manner.

† In each case to the farm costs of production must be added 13 cents for freight, 5 cents for handling charges, and 4 cents for the difference in grade between No. 1 and No. 2.

‡ The wholesale price index (1910-14 = 100) was 119.2 in March 1931. To have a purchasing power of 100, which would give a normal price of wheat, the wheat price index would have to be 119.2. Thus the theoretical normal yearly average price for wheat would be 96 cents (1910-14 yearly average) multiplied by 119.2, or $1.14 per bushel.

FIGURE 10

CHANGES IN THE MONTHLY PURCHASING POWER OF №1 NORTHERN WHEAT AT FT. WILLIAM 1890 TO 1930

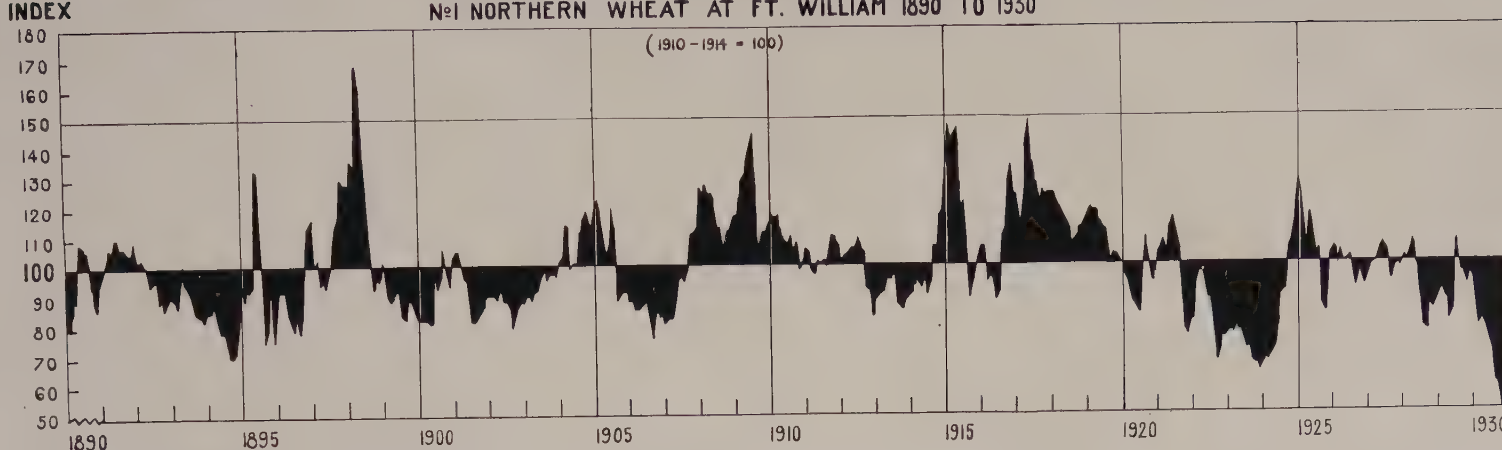

Figure 10. Changes in the monthly purchasing power of No. 1 Northern Wheat at Ft. William 1890 to 1930.

During the period of rising prices, 1896 to 1920, the purchasing power of wheat was usually below 100 for about two years at a time. Since deflation started in 1920 the periods below 100 have tended to be of longer duration. In the depression of 1894 the purchasing power dropped to a low of 69. Following the post-war depression the purchasing power reached a low of 66. In December, 1930, the purchasing power was 48.

FIGURE 11

THEORETICAL LONG TIME NORMAL PRICE FOR № 1 NORTHERN WHEAT AT FT. WILLIAM 1890 - 1930

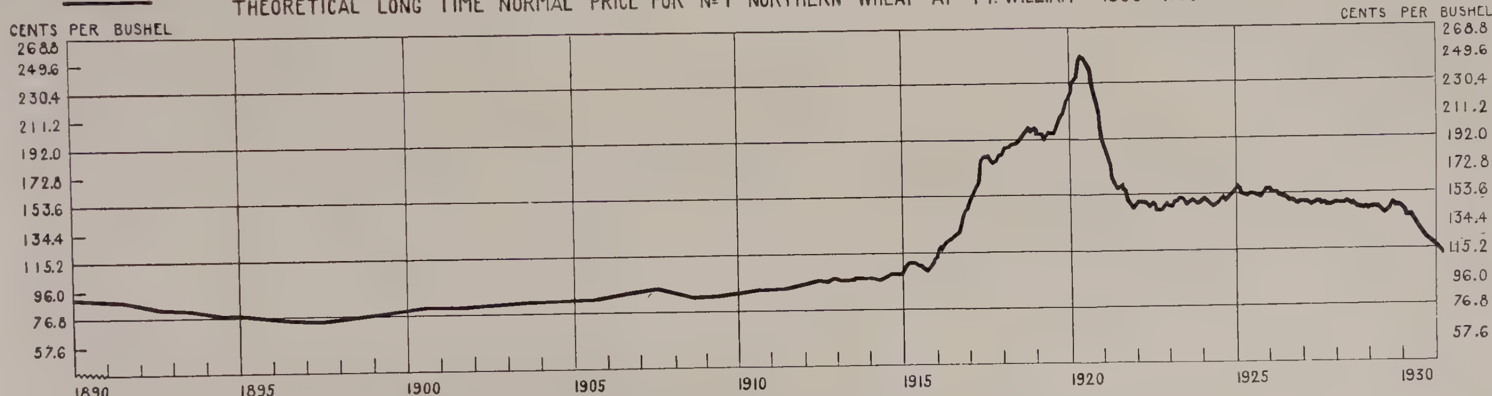

Figure 11. Theoretical long time normal price for No. 1 Northern Wheat at Ft. William 1890-1930.

The long time, or normal price for wheat has gradually fallen since 1925. With the gradual return of the general price level to a pre-war or lower level within the next 10 years or so, it is to be expected that the normal price for wheat will also decline.

operation or other causes, then the normal price of wheat would be considerably higher than $1.14. On the other hand if there should be a further drastic decline in the price level within the next few years the normal price for wheat would be lower.

The difference between $1.48, the average normal price for wheat from 1925 to 1929, and the probable normal price of wheat of $1.14 is 34 cents per bushel. It would appear that the farmers of the West will have to bear most of this reduction in price and it will therefore be necessary for them to reduce their costs per bushel by an amount equivalent to a large part of this 34 cents. This is a drastic cut in the cost of production. It cannot very well be done at present prices for the implements of production and present fixed charges. Many people unfamiliar with the West have assumed that the combine might make up for the difference in costs. However, it is very doubtful if this method of harvesting even in its most favorable operation, can save more than 10 cents per bushel over the binder-thresher method (9). Where the windrower has also to be used the saving would be considerably less. It should also be recognized that there are large areas of Western Canada in which the combine in its present form cannot be considered a sound investment.

The Outlook for Saskatchewan Producers

Before discussing ways and means of producing wheat on the Canadian prairies to sell at about $1.14 per bushel, basis No. 1 Northern at Fort William, it would be profitable to see what reasons there are for believing that such a recovery in wheat prices is possible, or probable. Present indications do not lead one to believe that the recovery in wheat prices will be immediate, or that the 1931 crop will sell at substantially higher prices than now prevail, (April 1931). In spite of this, there is a sound economic basis for the statement that there will be a return of the price of wheat to its normal relationship with other prices.

Probably the most spectacular item of bearish character on the wheat market for the past year has been the re-entry of Russia into the wheat exporting business on a fairly large scale. In all probability large Russian exports of wheat will continue, but with variation from year to year. It is unlikely that the extension of wheat acreage solely for the purpose of exporting grain will long continue, even in a socialistic state if returns are out of line with production costs. Limitations to the extension of Russian wheat acreages have to be recognized. As the lands most readily adapted for wheat growing are the first to be utilized, the later introductions for wheat growing must be considered more problematic and speculative. The continuous use of land for wheat production soon proves unsatisfactory. The problems of moisture deficiencies, control of weeds, plant diseases and insect pests, depletion of soil fertility, and the general soil management are serious ones, particularly in areas with scanty rainfall and frequent high winds. Measures to counteract these difficult conditions soon become imperative and these will considerably reduce the acreage available for wheat production. It must also be recognized that a steadily growing population and a rising standard of living will rapidly increase the Russian domestic wheat requirements, with consequent effect on her wheat exports. The purchasing of

Russian wheat by importing countries will continue whenever prices for this grain are sufficiently attractive. Whenever Russia's need for machinery or other industrial equipment is greater than her need for wheat, as at present appears to obtain after the big crop resulting from the favorable season in 1930, then exports of her wheat may be expected in order to secure the commodities most urgently needed.

The increase in acreage of Russian wheat has been accompanied by a serious decrease in livestock in which draft horses have been included. During 1930 the numbers of draft horses decreased 8 per cent; cattle 12 per cent; hogs 30 per cent; and sheep 25 per cent. These heavy declines resulted from wholesale destruction of animals by the wealthier peasants, who objected to turning over their livestock to the collective farms. A recent decree prohibits the slaughter of certain classes of domestic animals until December 31, 1931 (*10*).

One of the most important economic reasons for believing in the return of wheat prices to their normal relationships with all other prices is the reduction of wheat acreage that will result from the low wheat prices at present prevailing. Current reports indicate reductions for the 1931 crop in North America, Argentina, and Australia. These reductions will probably be of greater dimension if wheat prices continue for long at the present low level. The longer wheat prices remain very low the more likelihood there is that wheat acreage will continue to be reduced, and also the more likelihood that wheat prices will recover. With the recovery from the world-wide business depression, the prices of all raw commodities, including wheat, may be expected to regain their favorable relationship with other prices,—which relationship would bring wheat prices at, or about the level previously indicated.

What are the economic consequencies of permanently lowering the price of an agricultural commodity by an amount equivalent to some 25 per cent of the price previously obtained by the producer? If under the price previously prevailing many producers were finding success difficult to obtain how can their farm businesses be satisfactorily readjusted to the new condition? These are questions that have to be answered by the producers. Permanent agriculture can only exist where costs are less than returns, therefore if returns drop permanently 25 per cent and this drop is greater than the margin which previously existed between returns and costs, somehow adjustments must be made if the businesses are to continue. If costs are to be reduced, how will cost reduction be brought about?

Costs of production of grain on Saskatchewan farms vary widely but the average cost is around $14. per acre of crop.* Of the total acreage of crops about 25 per cent is used on the farm leaving about 75 per cent to produce cash revenue directly. The average net cost of production per acre of crop sold for cash is about $18.66, which, for the average yield of wheat for the province, is very close to $1.25 per bushel. These costs are usually about 50 per cent cash costs, and 50 per cent non-cash costs. The non-cash costs include the value of the operator's labor and management, and the interest on the total farm capital at 6 per cent. Adjustments have been made

* Farm Management Department, University of Saskatchewan surveys of 1925 to 1929 crop years.

to take care of inventory changes. The cash costs are solely for the operating of the farm, and do not include capital investments, or interest on loans. Based on two surveys made in 1930 in which over 400 Saskatchewan farms were included, interest due on farm loans amounted to about $285 per farm* and farm family living cash costs $900 per farm. These two items were equivalent to approximately 75 per cent of the net cash costs of crop production,—or about 46 cents per bushel of wheat. This is only 18 cents less than the total non-cash costs previously mentioned.

When the farmers are able to secure the full returns of cash costs and non-cash costs, and are comparatively free from indebtedness and also keep down cash living costs, considerable savings are usually possible. These savings are seldom in cash, but show as improvements and developments of the farm business, and are generally expressed as increases in net worth, much of which is in the farm land and buildings.

The values of the factors of production depend upon their earning capacity. If, after allowing for all costs of production, other than for the use of land, there remains annually $4.50 per acre of land, the value of that land, on the basis of 6 per cent interest rate, is $75 per acre. If the costs other than for the use of land equal the total returns from the crops raised, the land has no value in that line of production. Should the annual returns from crops sold from this land decrease by $4.50 per acre, and at the same time the annual costs of production other than for land use decrease by $1.50 per acre, then there still remains $1.50 as the annual earnings of the land, and thus its value would be $25 per acre.

From the Saskatchewan farm surveys it is indicated that approximately two-thirds of the non-cash costs are for interest on the total farm capital, which interest amounts to about 43 cents per bushel of wheat.

Land values represent two-thirds of the total farm capital, interest on which is approximately 28 cents per bushel of wheat. The reduction of wheat prices by 30 cents per bushel is greater than the interest on the value of the farm land by some 2 cents per bushel. If costs other than for the use of land continue unchanged then it might be stated that the values of these lands for *wheat production* have been reduced to something less than nothing,—(to about—$2 per acre of land, or—$5. per acre of wheat.) As some of the costs of wheat production other than for land use may be reduced, and costs of handling and transporting this product may also be lowered, it should not be expected that the values of land in wheat production will vanish, although it may reasonably be expected that they may seriously decline.

Assuming a serious decline in land values assumes a corresponding decrease in the total farm capital. Official estimates indicate that during 1930, land values declined in Western Canada, and in the North Western United States, and that further declines are to be expected in 1931. Future land values in Saskatchewan are likely to be based on their estimated earning powers in agricultural production, as speculative interest in agricultural land has virtually disappeared.

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* Average farm debt—Kindersley $4,804; Real estate 80.7; Farm implements 7%; Bank loans 8.6%; Store and miscellaneous 3.7%; Turtleford. $2,262; Real estate 66.3%; Farm implements 8.3%; Bank loans 8.7%; Store and miscellaneous 16.7%

Decreases in the values of farm lands are particularly significant to farmers having considerable indebtedness, and also to those to whom the debts are still owing. Substantial decreases in the values of farm products of a permanent character bring large decreases in the values of farm lands, make the farmers' debts much harder to pay, and may even wipe out the farmers' entire equities in their farms. Even farmers whose business methods and financial positions have been of a superior order have found themselves unable to meet the temporary store and business credit extended for the last operating season, (1930). In consequence, further credit through the ordinary channels is now completely withheld from farmers.

The difficulties of the farmers have also brought serious difficulties for the local storekeepers and tradesmen, who are now finding it increasingly difficult to carry on. The agencies having funds loaned to agriculture are becoming seriously concerned over their investments. They realize that neither interest nor principal of loans are being paid, and that there is danger of their investments becoming impaired, or completely lost, unless the most careful plans are made. Foreclosures of land are not normally desired by either lenders or borrowers. There is urgent need to know what is the real value of land in production so that the farmers may be able to decide as to the solvency of their businesses, and also that the loaning agencies may be able to judge as to the soundness of their investments and may be enabled to determine policies and plans for future loaning operations. Adjustments in loaning programmes are essential, both for loans already placed, and for future business. For existing loans, such adjustments must provide for well-considered and voluntary reduction of the principals, or of the interest rates, or of both principals and rates of interest. In the adjusted loans it is essential that the borrower be given at least a fighting chance of meeting his obligations from his farm operations as the nominal farm owner. It is also desirable that a considerably higher degree of agricultural stability be attained in order to establish security for loans to re-attract loanable funds to Western agriculture.

The period of adjustment in land values is a perplexing one to local, provincial, and federal government administrators. The securing of funds for their programmes is dependent on the success of industry generally, and, for Western Canada, for agriculture in particular. There are ever-increasing demands by the people for the provision of additional facilities for education, health, insurance, transportation, general communication, and for other purposes. These services have to be paid for. They are not less costly because they are community projects, or because the funds for their operation come largely through the channels of taxation. In many areas the burdens of taxation added to those of operating the farms have been greater than the businesses could stand, and abandonment of holdings has resulted. Abandoned holdings seldom produce revenue for municipal administrations, but do not materially reduce the demands on municipal funds. As these funds must come from fewer people, and from less land, the tax burdens for the farmers remaining increase with each abandonment, and appreciably induce further migration from farms.

In many Saskatchewan districts community development was most active when prices were at, or near the peak. The borrowings for these community projects were made when interest rates were high, and dollars were cheap in terms of farm products. At the present time, as a result of these borrowings, heavy demands are being made on agriculture to meet interest and principal on bonds of municipalities, school districts and rural telephone companies, when dollars are extremely costly in terms of farm products. Under these conditions it is difficult to give sound public administration. It is extremely important that further commitments be cut to the absolute limit until Saskatchewan agriculture can become satisfactorily readjusted. Under the heavy burdens of provincial and municipal administrations farming is being seriously distressed. Comprehensive studies of these difficult problems by competent persons are urgently needed to consider the possibilities of making sound plans for consolidation of services and reductions of costs of administration.

Any reduction of wheat producing costs obtained by decreases in interest charges as a result of decreases in land values simply constitute an acknowledgement of an unwanted economic change. Something more constructive is desired to help in the radical adjustment to lower wheat prices. The factors of production other than the farm lands merit consideration in this discussion.

On Saskatchewan farms the purchase and operation of equipment plays an increasingly important part. In the spring of 1931, farm equipment cost nearly two-thirds more than it did prior to the war. Prices for farm machinery have not been reduced materially since 1922. It is to be expected that farm machinery prices will soon have to be adjusted to lower levels, or farmers' purchases will continue at the minimum.

The wages of farm labor will be lower in 1931 than for many years, and may be expected to continue low until conditions improve in agriculture, or a demand for labor is developed in other industries. This is not a particularly desirable condition for farmers unless they hire considerable labor, as farmers generally are more nearly laborers than capitalists. On most farms, however, decreases in wage rates and the total wages paid will help to reduce production costs.

Non-agricultural commodities entering into general farm operations can also be expected to show declines in prices. Some have already done so. Gasoline prices in Saskatchewan dropped 4 cents per gallon from October 1st 1930 to May 1st 1931, which will substantially lower the operating costs of tractors. With industrial wage cuts generally introduced, and with lowered prices of most commodities, reduced freight rates should be expected. This is practically the only way in which reductions in the handling costs of agricultural products can be brought about. Some slight stimulation of the prices of wheat should follow as a consequences of lower freight rates. With the operation of the export route through the Hudson's Bay some further reductions in transportation costs of wheat are looked for by many Saskatchewan farmers.

During the next few years many of the bonds floated for rural development will be due for retirement. When this has been satisfactorily arranged for, financial demands on tax payers may be lightened to some extent. Lower prices for commodities, and lower wages for labor should also be reflected in lower taxes.

In addition to these limited possibilities of reducing costs of production there are possibilities of reducing the costs of living on the people of the farms. Current studies show considerable amounts of cash are expended in purchasing supplies for farm family living. Not all of these expenditures can be eliminated, but some modification of the present practices will be brought about by necessity. The modification need not be considered a radical reduction of living standards but rather the adoption of a higher degree of self-sufficiency. For the most of Saskatchewan agriculture it is sound farm management to produce what is required for home consumption of milk, cream, butter, eggs, poultry, pork, beef, veal, and garden products. Under suitable conditions, more emphasis on livestock may be permanently advisable. Good judgment should be used in selecting and balancing farm enterprises, and a policy of jumping in and out of livestock should be recognized as uneconomic and conducive to financial disaster.

At this time, more than ever, good farm planning and practices are imperative. These who have farm records should study them carefully and place themselves in a position to know definitely the status of their farm businesses. Over half of the operators of Saskatchewan farms fail to get the full cash and non-cash costs of production, and consequently make little progress. At the same time, some farmers are producing at very low costs and finding wheat growing generally remunerative. The economies of a farm of efficient size will be particularly significant in permitting effective use of labor and equipment in our future operations. The importance of suitable work done as cheaply as possible, must be stressed. Whether horses, or tractors, or a combination of both kinds of power will prove the most economic will depend on the particular farm business. If larger farms are needed to produce wheat efficiently, possibly these may come from the combination of smaller holdings by renting or purchase. The practical application of the most up-to-date information on farm problems, and the use of the most approved strains of plants and animals for each area of the prairies will be well repaid. It will be increasingly difficult for farmers to be definitely successful during these years of continued deflation. Periods of economic adjustment are of necessity difficult and painful, and bring many business failures, from which the farming industry is not exempt. The most inefficient areas for wheat production must go out of wheat-growing and the least efficient producers must gradually be displaced. The Canadian prairies can be made to produce wheat at considerably lower costs than those generally prevailing but can only do so by the adoption of sound business methods of farming. Only with an intelligent appreciation of the possibilities and limitations of Saskatchewan wheat growing can the permanence of Saskatchewan agriculture be assured.

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VERTICILLIUM WILTS IN ONTARIO

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In 1923 the senior author began a study of a raspberry cane disease prevalent throughout the Niagara Peninsula, which was ultimately found to be caused by *Verticillium ovatum* Berk. & Jack.‡ Since then, fungi of the genus Verticillium have been isolated in Ontario from potatoes, tomatoes, egg plants, maples, barberries, peaches, roses, raspberries, snapdragons and chrysanthemums. Verticillium wilts are thus seen to be quite common throughout the province and have caused serious individual losses at different times, particularly in egg plant, potato and raspberry plantations.

Up to date, some thirteen forms of Verticillium have been isolated in Ontario from ten hosts of economic importance. The question arose, whether all these hosts were attacked by the same form or whether there were several forms attacking different hosts. A study to ascertain this was started in 1924 and has been carried on as a minor problem till the present time.

The present paper deals mainly with the identity of *Verticillium albo-atrum,* particularly as it relates to its resting condition.

Literature

In recent years a considerable amount of literature has been published relating to Verticillium wilts on various hosts and particularly to the subject of the taxonomy of the species studied, Van der Meer (*18*), Pethybridge (*14*), Wollenweber (*19*), Carpenter (*4, 5*), Berkeley and Jackson (*1*), Berkeley (*2*), Rudolph (*16*) and others.

The first description of a Verticillium attacking plants of economic importance was published by Reinke and Berthold (*15*) in 1879. They described a wilt disease of potato and called the fungus responsible, *Verticillium albo-atrum.* Since then various investigators have attributed wilting in many different plants, often of widely separated families, to species of Verticillium. In most cases the fungus has been considered to be *V. albo-atrum* although the individual descriptions are far from similar. For instance, Carpenter (*4*) considered the wilt of okra, potato, gossyjium and antirrhinum to be caused by *V. albo-atrum,* though his description of the species definitely mentioned "sclerotia". Jagger and Stewart (*11*) and Pethybridge (*14*), on the other hand considered the wilt of potato to be caused by *V. albo-atrum*, and their description, while including dark resting mycelium, contained no reference to "sclerotia".

There exists today, therefore, a difference of opinion as to whether or not *V. albo-atrum* produces "sclerotia". Klebahn (*12*), Van der Meer (*18*), Pethybridge (*14*), Zimm (*20*), Berkeley (*2*), Berkeley and Jackson (*1*) and others are of the opinion that *V. albo-atrum* is without "sclerotia". Carpenter

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† Contribution from the Division of Botany, Experimental Farms Branch, Dominion Department of Agriculture, Ottawa, Canada.

‡ Verticillium wilt of Red Raspberry: G. H. Berkeley and A. B. Jackson. Scientific Agriculture, Vol. XI, No. 8, 1926.

(*5*), Bewley (*3*), Haenseler (*9*), Wollenweber (*19*), and Rudolph (*16*) on the other hand, consider *V. albo-atrum* to produce "sclerotia".

Miss Van der Meer (*18*) has published a most interesting paper on "Verticillium-wilt of Herbaceous and Woody Plants", in which she describes *V. albo-atrum* as producing dark "resting mycelium" but not "microsclerotia", whereas "microsclerotia" are abundant in *Verticillium Dahliae*. She considers the two forms as distinct species. On the other hand, Wollenweber (*19*) in a recent paper considers *V. albo-atrum* as producing "sclerotia" and hence does not agree with the separation of *V. Dahliae* from *V. albo-atrum*.. Rudolph (*16*) has just published an account of the literature on "Verticillium hadromycosis" and concludes that *V. albo-atrum* should be considered as producing "sclerotia".

A perusal of the literature brings out the fact that the description of *V. albo-atrum* by Reinke and Berthold is capable of more than one interpretation. As a result there exist today different conceptions of the species as a whole and particularly of the resting condition. The present paper attempts to show, in the light of experimental and other evidence, that *V. albo-atrum* does not produce "sclerotia".

Since Reinke and Berthold (*15*) were the first to describe a Verticillium causing hadromycosis, it is generally agreed that this fungus (*V. albo-atrum* R. & B.) be considered the basis for consideration of other strains associated with hadromycosis. It is obvious, therefore, that before any headway can be made in a classification of the forms associated with hadromycosis, the identity of *V. albo-atrum* must first be settled beyond question.

This paper is presented in the hope that it will assist in clearing up the uncertainty that is now associated with *V. albo-atrum*.

Resting Condition in Genus Verticillium

In section Gliocephalum of the genus Verticillium there are two different types of resting condition. One type is composed of loose masses of dark thick-walled hyphae with numerous transverse septa, the individual cells of which are torulose, somewhat resembling chlamydospores, or, may be little differentiated from the rest of the mycelium, (figures 1-4). The other type is composed of dark, knot-like, thick-walled structures, the result of budding of a single hypha, (figures 6, 7, 8).

These two types of resting condition are quite different, the black mass in one case being the result of many dark hyphæ lying close together, and in the other case the black body is composed of mono-hyphal knots, the result of budding.

In the literature both these types have been referred to as "sclerotia", or "microsclerotia". We question, however, the advisability of calling either of these resting conditions "sclerotia". If a sclerotium is a compact mass of intertwined thick-walled to normal hyphæ with numerous transverse septa, enclosed within one or more darker-coloured cortical layers, it is quite obvious that the term "sclerotium" cannot be applied to either of these resting conditions. In the first type, the loose mycelial mass does not form any distinctive structure and certainly the intertwined hyphae are not within a cortical layer or layers. In the other type, the result of mono-hyphal budding, there are

neither intertwining hyphæ, nor cortical tissue differentiated from the rest of the structure. It seems therefore, that the term "sclerotium" should not be used for either of these resting conditions notwithstanding the fact that, in the past, both forms have been designated as "sclerotia".

We propose the term "resting mycelium" (Reinke and Berthold (*15*) for the loose-lying-together type and "pseudo-sclerotia" for the mono-hyphal, budded-knot type, definitions of which follow:

Figure 1. Drawing of resting mycelium of *V. albo-atrum.*

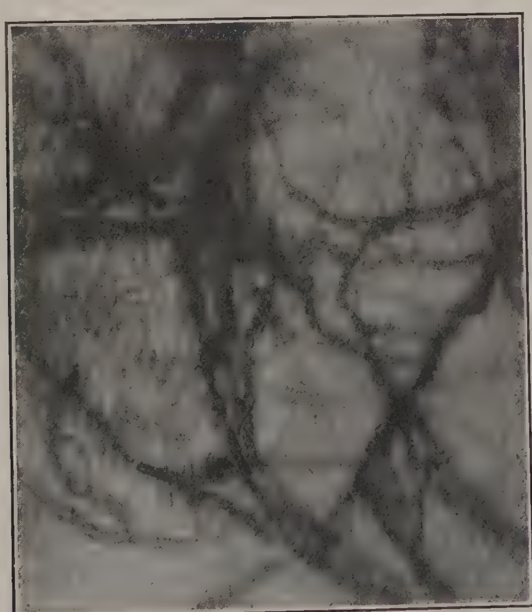

Figure 2. Photomicrograph (high power) of normal darkened hyphae.

Resting mycelium: Masses of dark, thick-walled hyphæ with numerous cross walls, the individual cells of which are torulose, somewhat resembling chlamydospores, or may be otherwise little differentiated from the rest of the mycelium.

Pseudo-sclerotia: Mono-hyphal, thick-walled, dark, coloured, tissue-like formations, the result of a budding process.

Cultural Studies

During the past seven years we have had many forms of Verticillium under culture. During this time we have made hundreds of isolations from many different hosts and so far the great majority of the cultures fall into two

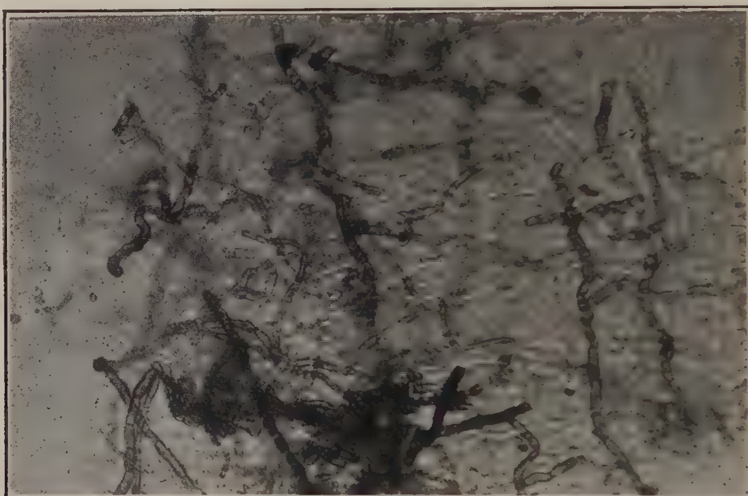

Figure 3. Photomicrograph (high power) of torulose and normal darkened hyphae.

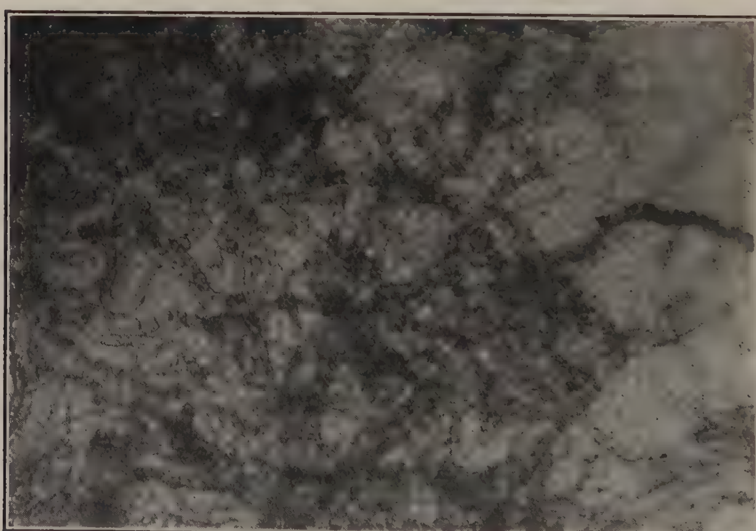

Figure 4. Photomicrograph (high power) of mass of resting mycelium showing one long torulose hypha.

groups on the basis of their resting condition, namely, group (A) with resting mycelium only, and group (B) with pseudo-sclerotia.

Before taking up the characteristics of these two groups it should be pointed out that all cultures worked with have been proved by inoculation and reisolation to produce hadromycosis and secondly, that every culture used, without exception, was of monosporous origin. Standard potato agar was used as culture medium.

(A) *The resting mycelium group* (*Verticillium albro-atrum R. & B. type culture*)

In 1925 Miss Van der Meer sent us a culture of *V. albo-atrum* which she had isolated from potato.

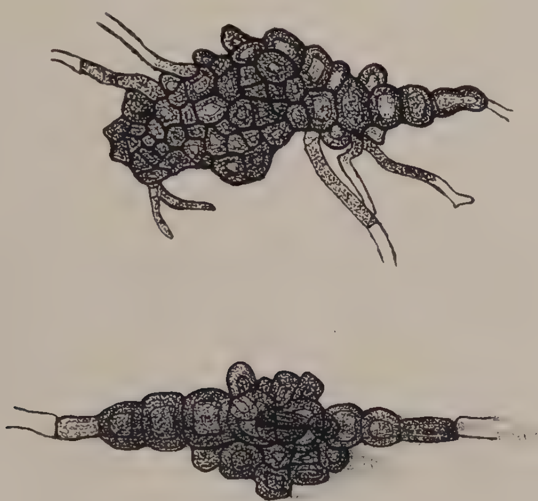

Figure 6. Drawing of pseudo-sclerotia.

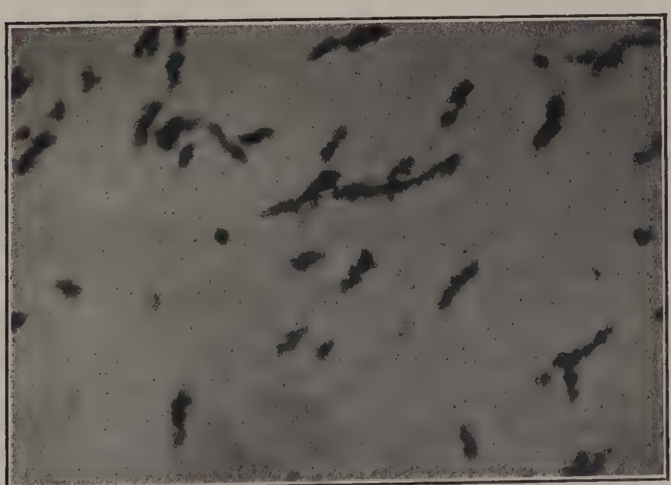

Figure 7. Photomicrograph (low power) of pseudo-sclerotia.

In 1925 a Verticillium was isolated by the senior author from potatoes sent in from northern Ontario (*V. albo-atrum*).

In 1926 a Verticillium was isolated by the senior author from tomatoes sent in from northern Ontario (*V. albo-atrum*).

In 1930 two cultures of *V. albo-atrum* were obtained from the Centraalbureau voor Schimmelcultures. These were isolated by Van der Veen.

All these cultures when obtained, produced darkened, septate hyphae, but no true mono-hyphal pseudo-sclerotia. During all the time that we have had these forms in culture, they have at no time produced anything even approaching mono-hyphal pseudo-sclerotia.

It is true that with continued culturing these forms began to produce less and less "resting mycelium", until finally none was to be seen even after a careful microscopic examination. Other workers have also recorded this loss of production of specialized hyphae. However, such forms do not actually lose the power of producing the "resting mycelium" as can be shown by transfers made on to sterilized potato sections. In every case, so far attempted, the black "resting mycelium" has been restored by growing on potato plugs, (Carpenter 5)). For instance, the culture of *V. albo-atrum* received from Van der Meer in 1925 produced darkened "resting mycelium" for two transfers only after it was received at this laboratory. From that time, 1925, till 1929 it did not produce any "resting mycelium" but on making transfers to potato plugs early in 1930, it was noted that black "resting mycelium" was present. From that time to the present (May, 1931) this form has been producing "resting mycelium" on potato plugs. However, when transfers are made to potato agar, the black resting mycelium may appear for only two or three transfers when again it is conspicuous by its absence. But it can be restored again by transferring to potato plugs. The other four cultures of *V. albo-atrum* have acted in a similar manner. That is, we have had under observation five different strains of the fungus Verticillium which produce the usual whorled conidiophores associated with the genus and a resting condition in the form of darkened, many septate thick-walled hyphae. At no time have any of these cultures formed anything resembling mono-hyphal pseudo-sclerotia although they have been grown on many different media and on many living hosts. Some of these forms have been in culture for six years. It seems reasonable therefore, to assume that these forms do not produce pseudo-sclerotia.

(B) *The pseudo-sclerotium group (Verticillium Dahliae Kleb., type culture)*

From 1923 till 1928 thirty-two different forms of the pseudo-sclerotium type have been obtained from thirteen different hosts. These cultures were secured from Holland, United States of America and Ontario, Canada. In every case they have continued to produce pseudo-sclerotia, although at times the amount has been almost negligible. However, as in the case of members of the resting mycelium group, so here, transfers made to potato plugs have resulted, in all cases tried, in a restoration or increase of the production of pseudo-sclerotia. It is worthy of note that *V. Dahliae* Kleb., received from Centraalbureau voor Schimmelcultures, Holland, in 1925, and identified as such by Klebahn, has been exceedingly constant in its pseudo-sclerotium production from that time to the present. It has produced at all

times, on potato agar, pseudo-sclerotia in abundance. Many other pseudo-sclerotium forms from different hosts such as potato (Holland 1923), maple (Canada 1923), maple (U.S.A. 1925), barberry (Canada 1925), aster (Canada 1925), tomato (U.S.A. 1925), raspberry (Canada 1925 and U.S.A. 1925) are also still producing pseudo-sclerotia on potato agar. There is not the same tendency for members of this group to lose the power of producing pseudo-sclerotia as is the case for members of the other group to lose the power of producing resting mycelium.

(2) Inoculation Studies

Cross inoculation studies with some thirty-seven strains on thirteen different hosts, have been under way during the past six years. In the present paper the pathogenicity of *V. albo-atrum* and *V. Dahliae* only is given.

Although different methods of inoculation have been tried, the bulk of the work has been done by adding to the roots of a plant through the soil, a spore suspension of the fungus. In this connection it has been observed that greater percentages of wilt will result with small seedling plants when the inoculations are made at time of transplanting than when the spore suspension is applied to larger plants that have become firmly rooted in the soil.

It has been observed that, although some forms are consistent in their attack on any one host, other forms are not. The inconsistent results obtained, are to be explained, we think, by the fact that many of the forms are weak parasites and therefore easily affected by change in temperature and general environmental conditions.

All inoculations were carried out under greenhouse conditions using sterilized soil. The temperature of the house was held around 20°C. as much as possible. It should be pointed out, however, that since the greenhouse used for these tests was not equipped with automatic temperature or moisture controls, no standard conditions were possible during the long period over which these experiments were continued. On the other hand, this lack was largely overcome by the fact that inoculation tests for any form were carried out on a large number of plants, often over seventy-five, spread over a six-year period under various seasonal growing conditions, and fairly consistent results were obtained. Positive results of inoculations were based on external signs of wilt and re-isolations in every case.

Some inoculations were attempted outdoors, but due to many natural infections on checks as well as inoculated plants, the outdoor series was abandoned.

In the interest of brevity and clarity the members of the resting mycelium group are hereafter collectively called *V. albo-atrum*. When the type culture of the group is referred to it is designated as *V. albo-atrum* R. & B. (sp). Likewise in the case of the pseudo-sclerotium group, the members are collectively called *V. Dahliae*, but the type culture is referred to as *V. Dahliae* Kleb. (sp). We consider the form which most closely resembles Reinke and Berthold's original description as to spore size and shape, mycelium, conidiophores, pathogenicity, etc., to be *V. albo-atrum* R. & B. (sp.). In the case of *V. Dahliae* Kleb. (sp.), we consider the culture that we obtained from Holland, and which was identified by Klebahn, to be the type culture.

There is no attempt made in the present paper to go further in the matter of classification than to establish these two groups.

Besides other minor differences the fact stands out clearly that the members of the *V. albo-atrum* group are stronger parasites than those of the *V. Dahliae* group (Van der Meer (*18*), Wollenweber (*19*)). We have found this to be true with all host plants so far used, namely, tomato (Grand rapids), potato (Irish Cobbler), snapdragon (seedlings and clon line) and cucumber (Black Spine). Not only does wilt show up sonner in the case of *V. albo-atrum* but in addition it is more severe, particularly on potato and tomato.

The results of one experiment will illustrate this point. A series of seventy-five tomato plants was inoculated with different strains of *V. albo-atrum* and *V. Dahliae*. In ten days wilt was apparent o nall tomato plants inoculated with *V. albo-atrum* while the plants inoculated with *V. Dahliae* showed no symptoms of wilt whatever until after nineteen days, and even then the symptoms were so slight as to be doubtful. After thirty days the plants inoculated with *V. albo-atrum* were decidedly sickly, showing yellowed and dried up leaves some considerable distance up the plant with a general stunting and wilting of the foliage. In the case of plants inoculated with *V. Dahliae*, only the lower foliage showed any yellowing and although no definite wilting was apparent, the plants were slightly stunted. In other words, except for the yelllowed leaflets at the bottom of the plant, these plants appeared fairly helathy though stunted. *V. Dahliae* Kleb. (sp), however, is a weak parasite on tomato whereas *V. albo-atrum* R. & B. (sp) (and group as a whole) is a strong parasite. Van der Meer (*19*) likewise found *V. albo-atrum* a stronger parasite on tomato and potato. It might be pointed out here, however, that some members of the *V. Dahliae* group, according to our experiments, are much stronger parasites on tomato and potato than is *V. Dahliae* Kleb. (sp).

In an experiment on a clon line of snapdragons it was found that after nineteen days all plants inoculated with *V. albo-atrum* began to show wilt, while the plants inoculated with *V. Dahliae* Kleb. (sp) did not produce wilt after two months' time. It should be pointed out here, however, that on one occasion, we re-isolated *V. Dahliae* Kleb. (sp) from inoculated snapdragons that showed no signs of wilting or any other adverse effects whatever.

In another experiment with snapdragon seedlings, somewhat different results were obtained as is shown below. Fifteen plants were inoculated with each strain. In this case, the seedlings were inoculated at time of transplanting and within a month all forms of *V. albo-atrum* had produced wilt, and some forms of the *V. Dahliae* group also produced wilt, but *V. Dahliae* Kleb. (sp) did not. The plants inoculated with *V. Dahliae* Kleb. (sp) were perfectly healthy at the end of the experiment.

A comparison of these three experiments brings out the fact that the stronger parasites in all cases belonged to the *V. albo-atrum* group, while the weaker parasites belonged to *V. Dahliae* group. In fact *V. Dahliae* Kleb. (sp) was unable to produce wilt even on the seedling snapdragon plants that were inoculated at time of transplanting. In the last four inoculation tests on snapdragon (twelve plants inoculated with each strain(*V. Dahliae* Kleb (sp) has in no case produced wilt.

We have stated above that *V. albo-atrum* is a stronger parasite than *V. Dahliae* Kleb. (sp) on tomato, potato and snapdragon, but much stronger evidence that they are physiologically different is shown by the following results obtained during the past five years by annual series of inoculation studies under greenhouse conditions.

In the first place we have been unable to date to produce wilt on cucumber with any of the thirty-two isolated forms of the *V. Dahliae* group including *V. Dahliae* Kleb. (sp). On the other hand the five forms of *V. albo-atrum* all produced definite wilt on cucumber in anywhere from fifteen to thirty-eight days' time. Secondly, all forms of *V. albo-atrum* produced definite wilt, with ultimate death, on snapdragon seedlings or mature clon line plants in anywhere from fourteen to fifty-nine days, whereas *V. Dahliae* Kleb. (sp) did not produce wilt on snapdragon although other members of the *V. Dahliae* group may do so. Thirdly, we have been able to produce wilt in dahlia seedlings (*D. variabilis*) with *V. Dahliae* Kleb. (sp) only. All members of the *V. albo-atrum* group and all other members of the *V. Dahliae* group have so far given negative results. In the case of dahlia we have produced wilt with *V. Dahliae* (sp) only four times out of some fifteen different attempts, so it would appear that the form we secured from Holland in 1923 as *V. Dahliae* Kleb., which was identified by Klebahn, is a weak parasite on dahlia, under the conditions of our experimental work.

That Verticillium species are greatly influenced by environmental conditions is evidenced by the wide range of incubation periods recorded in the above experiments. The following table gives the incubation periods of a single strain of *V. albo-atrum* on potato (Irish Cobbler), snapdragon (seedlings) and tomato (Grand Rapids). It should be pointed out that the same source of sterilized soil was used throughout so that the only variable factor for any given host was the environmental condition of the greenhouse.

Host	*Date inoculated*	*Inoculum*	*Incubation period in days*
Potato	Feb. 22, 1929	*V. albo-atrum*	11
	Dec. 7, 1929	"	84
	Apr. 3, 1930	"	30
	Dec. 8, 1930	"	35
	Feb. 13, 1931	"	34
Snapdragon	Nov. 19, 1929	"	51
	Mar. 10, 1930	"	59
	Nov. 27, 1930	"	18
	Nov. 28, 1930	"	20
	Mar. 19, 1930	"	50
	May 20, 1930	"	49
	Dec. 15, 1930	"	14
Tomato	Jan. 15, 1929	"	52
	Dec. 7, 1920	"	39
	Jan. 17, 1930	"	19
	Mar. 5, 1930	"	69
	Nov. 26, 1930	"	10
	Jan. 16, 1931	"	46

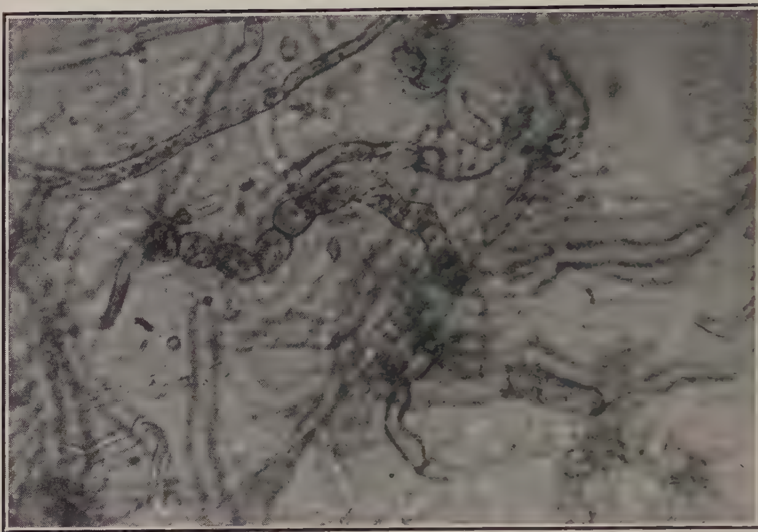

Figure 5. Photomicrograph (oil immersion) of a section of a torulose hypha of *V. albo-atrum.*

The above results bring out a great difference between the dark coloured resting mycelium group, *V. albo-atrum*, and the dark pseudo-sclerotium group, *V. Dahliae,* which along with the morphological dissimilarities mentioned above, support the placing of these forms in separate groups.

Discussion

There are in existence today, therefore, two distinctly different types of Verticillium fungi associated with hadromycosis. The members of the one type (*V. albo-atrum*) produce their resting condition in the form of darkened, many septate, torulose hyphae, but lose the power of producing this resting stage under continued culturing on artificial media, (figures 2, 5). In the other group (*V. Dahliae*) the resting condition is in the form of mono-hyphal pseudo-sclerotia and most members of the group do not lose the power of producing pseudo-sclerotia under conditions of continued culturing on artificial media (figures 6, 8).

From the standpoint of pathogenicity the members of the *V. albo-atrum* group are stronger parasites than the members of the *V. Dahliae* group. Cucumber is parasitised by the *V. albo-atrum* group only. There is, in addition, the further distinction between the type cultures *V. albo-atrum* R. & B. (sp) and *V. Dahliae* Kleb., (sp) in that *V. Dahliae* Kleb. (sp) is the only form that causes a wilt on dahlia.

In other respects the members of both groups are quite similar, i.e., both groups have the typical whorled conidiophores with spores held in heads. Although here again a slight distinction is to be seen in that the bases of the conidiophores of *V. albo-atrum* group are darkened, whereas such darkening is not found in *V. Dahliae* group (Klebahn (*12*), Van der Meer (*18*)). It should be pointed out, however, that the darkened base is found only in those cultures that still produce the resting mycelium. Cultures which have temporarily lost the power of producing resting mycelium do not produce the

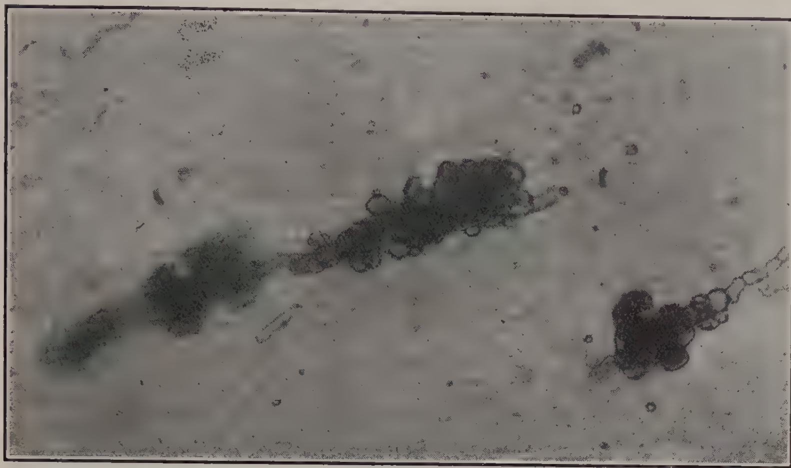

Figure 8. Photomicrograph (high power) of pseudo-sclerotia.

darkened bases of conidiophores. This power is, however, restored by culturing on potato plugs.

In so far as general appearance of culture is concerned, other than the resting condition, there is great similarity between the two groups. The spore size and shape, measurements of mycelium, sporophores etc., are not particularly characteristic for either group.

Which of These Types Should be Considered *V. Albo-atrum* ?

The question therefore arises, which of these two groups most closely fits the description as given by Reinke and Berthold for *V. albo-atrum?* There can be no serious doubt but that group "A" which produces black masses composed of individual, darkened, resting hyphae with no budding or longitudinal walls, most closely resembles the description as given by Reinke and Berthold for *V. albo-atrum.*

As we interpret their description of *V. albo-atrum,* the forms as we know them under group "A" are in perfect agreement with their description. In fact we could describe our resting mycelial cultures with the identical words used by Reinke and Berthold for *V. albo-atrum*, namely, "In these hyphae numerous cross walls appear and the short cells grow in thickness and assume a globular form so that the hyphae appear torulose. If many such torulose hyphae *lie beside one another*, black cell heaps of different sizes and irregular shapes originate in the decaying tissues. The appearance of *longitudinal walls* was *never observed*. The brown cell heaps are thus formed *only* by the lying besides one another of neighbouring hyphae." The above description, given by Reinke and Berthold in 1879 for *V. albo-atrum,* can be as readily applied today, as it was then, to all cultures of the resting mycelium type that we have so far examined.

Reinke and Berthold call these heaps of "Dauermycelien", "Sklerotien", but in using the term sclerotia they say, "these resting mycelia *can be called sclerotia* even if their cells *do not form any larger tissue bodies* as is the case

in the *formations usually* designated as sclerotia".* Their statement clearly indicates that although they used the term "sclerotia" they themselves realized that their masses of "Dauermycelien" were not true sclerotia, hence the necessity for their adding "even though their cells do not produce any larger body of tissues, as in the case in formations usually termed "sclerotia". It seems to us that they might preferably have avoided the use of this term, since obviously the lying-together-of-darkened-mycelium, which they describe, was not considered even by themselves to be true "sclerotia" as already pointed out. Otherwise, why did they make the above explanatory statement concerning the use of the term.

We realize, however, that more than one meaning may be taken from the above statement of Reinke and Berthol. Although it is obvious that they were not entirely satisfied with the use of this term to describe their "Dauermycelien", it is not so clear as to what they meant by "do not form any larger tissue bodies". Did they mean that small tissue bodies were formed, but not the larger ones as are found in some sclerotia, or did they mean that tissue bodies were not formed at all? Both meanings seem to us to be possible. However, to answer this question in a satisfactory way we must consider this statement in relation to their description of the "Zellhaufen". They say that, "the cell masses or heaps are formed only by the lying beside one another of neighbouring hyphæ" and, "that no longitudinal walls were ever observed". It seems to us that these two quotations delete the possibility of their having in mind tissue bodies. That is, a mere heap or mass of torulose resting mycelium does not make a tissue body and if, as they say, no longitudinal walls were present, obviously the individual hyphal strands were not joined into a tissue. It is difficult to conceive of a tissue in which only transverse walls are present.

Our conception is, therefore, that Reinke and Berthold used "Zellhaufen" or "Sklerotien" to describe undifferentiated heapings of torulose resting hyphæ; and therefore they should be considered as resting mycelium and not as definite tissue bodies.

Further, we must however, accept Reinke and Berthold's statement that their so-called "sclerotia" or "Zellhaufen" were composed only of neighbouring torulose hyphae lying close together. There is no doubt whatever but that Reinke and Berthold were clearly of the opinion that this was the true manner of their production. There is no good reason to doubt that they misunderstood the origin of their "Dauermycelien" because they describe them fairly clearly, and what is more important, we have today forms of Verticillium that agree absolutely with their description. We must accept their descriptions therefore, as being correct. Such being the case, we are of the opinion that Reinke and Berthold erred only in the use of the term "sclerotia". They call their "Dauermycelien" sclerotia, but obviously since true "sclerotia" are never formed from torulose hyphal initials, such as Reinke and Berthold's so-called "sclerotia" originated from, the use of the term for the cell masses described by them is incorrect.

It is true, that since the time of Reinke and Berthold, the resting condition of Verticillium cultures in general has been designated by numerous

* Italics are ours.

investigators as "sclerotia" but we feel that this has resulted in confusion and that it would be preferable to discontinue the use of the term "sclerotia" when obviously there are no true "sclerotia" in the genus Verticillium. We have accordingly proposed the term "resting mycelium" which was first used by Reinke and Berthold.

Since Reinke and Berthold's time, however, another resting condition (our pseudo-sclerotia) has been found in the genus. (Our pseudo-sclerotia= sclerotia or microsclerotia of Klebahn (*12*), Van der Meer (*18*), Carpenter (*5*), Wollenweber (*19*), Rudolph (*16*) and others). We cannot accept that Reinke and Berthold had pseudo-sclerotia such as are found in *V. Dahliae* Kleb., in their *V. albo-atrum* because they do not describe or picture such formations. Whereas Reinke and Berthold's "Dauermycelien" or "Sklerotien" were composed of numerous hyphae lying close together, pseudo-sclerotia, as found in the genus Verticillium, are formed from single hyphae by a budding process. It is at once obvious that such a resting condition was not described or pictured by Reinke and Berthold for *V. albo-atrum*. Therefore *V. albo-atrum* should not be considered to produce pseudo-sclerotia (sclerotia).

It is inconceivable to us that anyone should describe the budded, knot-like pseudo-sclerotia, as found in *V. Dahliae*, as being "formed only by the lying beside one another of neighbouring hyphae" simply because such pseudo-sclerotia develop from a single hypha. That is, a pseudo-sclerotium being mono-hyphal could not possibly be formed by numerous hyphae lying close together as Reinke and Berthold state was the case with the "sclerotia" of *V. albo-atrum*. We therefore are of the opinion that Reinke and Berthold did not have in their *V. albo-atrum* such pseudo-sclerotia. In addition, Reinke and Berthold definitely state that the "resting mycelium" of *V. albo-atrum* does not produce larger tissue bodies whereas the pseudo-sclerotium of *V. Dahliae* is actually a solid tissue formed by budding. Also they state that no longitudinal walls were observed in their "Dauermycelien" whereas numerous longitudinal walls are observed in the pseudo-sclerotia of *V. Dahliae*. In the light of the above considerations it seems evident that Reinke and Berthold did not have pseudo-sclerotia (sclerotia) in their *V. albo-atrum* and therefore we today should not correlate pseudo-sclerotia with *V. albo-atrum*.

For the above reasons we are therefore of the opinion that Reinke and Berthold correctly described the origin of their "Dauermycelien" but were unfortunate in the use of the term "sclerotia" to describe them.

There is additional evidence that Reinke and Berthold's *V. albo-atrum* did not contain pseudo-sclerotia in that they were working with a form strongly parasitic to potato. From our experience (Van der Meer also) the resting mycelium forms (*V. albo-atrum*) are far more parasitic to potatoes than the pseudo-sclerotium forms. It is therefore most likely that Reinke and Berthold worked with one of the resting mycelium group as we know it today (as indeed we think their description clearly shows), because these forms are stronger parasites on potatoes than the pseudo-sclerotium forms. Also Reinke and Berthold specifically say that the bases of the conidiophores of *V. albo-atrum* turn black. From a comparison of our cultures we find that it is only in our "resting mycelium" group that the bases of conidiophores

turn black. This is therefore additional evidence that our "resting mycelium" forms are *V. albo-atrum*.

We contend that the experimental evidence recorded here, considered in the light of Reinke and Berthold's original description of *V. albo-atrum* justifies the conception that it should be considered to produce "resting mycelium" only, whereas *V. Dahliae* should be considered to produce pseudo-sclerotia.

Discussion of Certain Literature Relating to Resting Condition of *V. albo-atrum* and *V. Dahliae*.

Van der Meer (*18*) considers *V. albo-atrum* a "non-microsclerotial" fungus and *V. Dahliae* a "micro-sclerotial" fungus. She bases her consideration of these two species on their morphology in culture and on a series of cross inoculation studies along with a consideration of the original description of both species. In discussing her work Rudolph (*16*) says "Van der Meer's experiments are open to criticism because too few plants were used. In none of her experiments were more than four plants used and generally only one or two plants were inoculated with any given strain".

Although this criticism may be justified, we have been able to verify Van der Meer's work with these two species. We have isolated in Ontario the two types of Verticillium that she isolated. We have compared our isolations with hers and find them identical. In addition, our findings agree with hers in that *V. albo-atrum* (resting mycelium) is a much stronger parasite on tomato (Grand Rapids) and potato (Irish Cobbler) than is *V. Dahliae* (sp) and that *V. Dahliae* is unable to parasitise cucumber, although all members of the *V. albo atrum* group are equally parasitic on cucumber (White Spine). In this connection, it should be pointed out that it is quite possible that some strains of the *V. Dahliae* group will be found to parasitise cucumber but any that we have come across have been unable to do so, and certainly *V. Dahliae* Kleb. (sp) is not parasitic to cucumber.

We have presented additional evidence of a similar nature to show (1) that *V. albo-atrum* is also a stronger parasite than *V. Dahliae* on snapdragon seedlings and (2) that *V. Dahliae* Kleb. (sp) is the only form with which we have been able to cause wilt on dahlia seedlings (Dahlia variabilis). *V. albo-atrum* will not produce wilt in dahlia nor will the other members of the *V. Dahliae* group.

In connection with our pathogenic studies it should be specially pointed out that any single strain has been inoculated into at least seventy-five plants over a six-year period. The criticism made of Van der Meer's work therefore does not hold good here, and yet our results agree with hers. Such being the case, there seems to be every reason for considering such morphologically and physiologically different strains as distinct species.

Pethybridge (*14*), Van der Meer (*18*), Rudolph (*16*), Bewley (*3*), Klebahn (*12*), Zimm (*20*), Berkeley and Jackson (*1*), Edson and Shapovalov (*7*) and others have isolated or worked with a Verticillium fungus that formed resting hyphae and not pseudo-selerotia (sclerotia; microsclerotia). The pseudo-sclerotium form is, however, much more generally distributed and has also been isolated by the above workers and many others in various parts of the world. If both these forms have been repeatedly isolated over a long

period of years and can be easily distinguished from each other by their resting condition alone, surely such widely different strains within the genus should be considered separate species particularly when it is possible to correlate the different resting conditions of the fungus with pathogenicity.

Some investigators, notably Wollenweber (*19*) and Rudolph (*16*), consider *V. albo-atrum* to produce "sclerotia". Let us therefore consider the papers of both these investigators in so far as they relate to the resting condition of *V. albo-atrum.*

Wollenweber (*19*) prefers to consider *V. albo-atrum* to be a "sclerotial" fungus and thus the species would include *V. Dahliae* Kleb., *V. ovatum* Berk. & Jack., and all other pseudo-sclerotial forms probably. He disposes of the more rare fungus strain which produces "resting mycelium" as being a variety of *V. albo-atrum* which he named *V. albo-atrum* var. *caespitosum.*

Wollenweber in attempting to prove that *V. albo-atrum* should be considered a "sclerotial" (pseudo-sclerotial) fungus says, "From such initial phases as 'string of beads'—like chains or clumps of cells—resembling chlamydospores—which Reinke and Berthold figure in plate IX; 1 & 2, to sclerotial balls, respectively micro-sclerotia, there occur under circumstances within this identical race of the fungus all transitional stages (vide my illustration 4; a & d); and when R. & B. state that these sclerotia are formed only through a coremium-like association of hyphae, their illustrations, nevertheless, show that single hyphae may fork and thus produce double chains. From the latter to the formation of larger sclerotial structures is but a step. *Hence one may safely consider V. albo-atrum as a sclerotial verticillate fungus*".* By sclerotial fungus Wollenweber means our mono-hyphal, pseudo-sclerotia because his *V. albo-atrum* includes *V. Dahliae* Kleb., and *V. ovatum* Berk. & Jack., forms which produce this type of resting condition.

From our experience with different Verticillium forms during the past six years, we are inclined to a different view. We are of the opinion that the "resting mycelium" forms are truly *V. albo-atrum* for reasons already given. It is true that in certain forms there are all transitions from initial chains of chlamydospores to "sclerotial" knots or "micro-sclerotia" (pseudo-sclerotia) as mentioned by Wollenweber, but it is equally true that there are other forms in which all these stages are not found, i.e., there are forms in which the step from branched chains to "microsclerotia" (pseudo-sclerotia) does not take place and therefore such a step cannot be assumed for any. In the latter, the resting condition never goes beyond a darkening and rounding out of the individual cells of the mycelium. That is, no pseudo-sclerotia whatever are formed. The black colour of a culture of this type is therefore due to darkened, hyphal strands lying close together as described and pictured by Reinke and Berthold for the "Zellhaufen" of *V. albo-atrum* (*15*), (figures 2, 3, 4, 5). The black colour of a culture of the other type (*V. Dahliae*) is due to the formation of mono-hyphal pseudo-sclerotia, i.e., a single mycelial

* Quotation from Wollenweber's paper (19), page 274:

Von den Anfangsstufen, perlschnurartigen, Chlamydosporen ähnelnden Ketten oder Zellhaufen, die Reinke und Berthold in Tafel IX, 1, 2 abbilden, bis zu sklerotialen Knäueln bzw. Mikrogklerotien gibt es bei demselben Pilzstamme unter Umständen alle Uebergänge (vgl. meine Abbildung 4, A, D); und wenn Reinke und Berthold sagen, dass sich diese Sklerotien nur durch Aneinanderlagerung von Hyphen bilden, so zeigen doch ihre Abbildungen, dass einzelne Hyphen sich gabeln und dadurch Doppelketten entstehen. Von letzteren zu grösseren sklerotialen Gebilden ist aber nur ein Schritt. *Man kann also V. albo-atrum getrost als sklerotialen Wirtelpilz auffassen.*

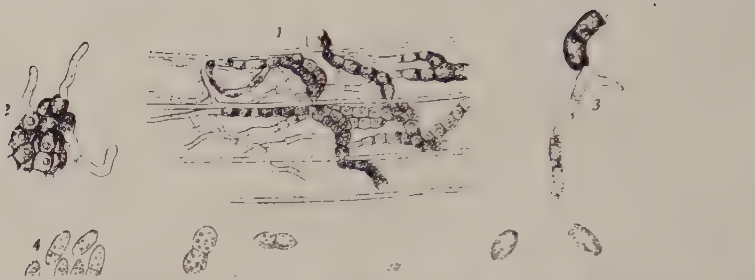

Figure 9. Photographic reproduction of Reinke and Berthold's Dauermycelien. Described by them as (1) *V. albo-atrum,* 'Bildung des Dauermycels in den Zellen des faulenden Stengels Form A (380/1); (2) u. (3) Keimende Dauerzellen (660/1). (After Rudolph.)

strand may form a large, tissue-like, compact sclerotium-like structure (figures 6, 7, 8).

It would seem to us that Wollenweber held this opinion because Reinke and Berthold used the term "sclerotia" to describe their "Dauermycelien", and also because in his cultures there were all stages from darkened resting hyphae through chains of chlamydospores to pseudo-sclerotia. As we have said, this is entirely true for certain cultures of Verticillium such as *V. Dahliae,* but it does not necessarily follow that because this is true of some forms, it is true for all. In fact it is not true for all because we have had five strains of *V. albo-atrum* in culture for years and none have ever produced anything beyond the "resting mycelium" stage. Of the two types of fungi, that is the "resting mycelium" type and the "pseudo-sclerotium" type, the "resting mycelium" type agrees perfectly with the description of *V. albo-atrum* as given by Reinke and Berthold and therefore should be considered to be *V. albo-atrum.* We cannot accept that Reinke and Berthold's description of the "sclerotia" (formed by the close lying together of specialized hyphæ) of *V. albo-atrum* should be considered to include mono-hyphal pseudo-sclerotia as such structures are directly opposed in origin to the so-called "sclerotia" of Reinke and Berthold.

Rudolph (*16*), like Wollenweber considers *V. albo-atrum* to be a "sclerotial" (pseudo-sclerotial) fungus, though for different reasons. He suggests that *V. albo-atrum* be considered a true "sclerotia" (pseudo-sclerotia) producing fungus and the form which regularly produces "carbonized" hyphae and no "sclerotia" (pseudo-sclerotia) be considered a variety which he names *V. albo-atrum,* var., *tuberosum.* Wollenweber's *V. albo-atrum* var. *caespitosum* and Rudolph's *V. albo-atrum* var. tuberosum are therefore synonyms.

Rudolph says: "Reinke and Berthold have drawn a structure which, while somewhat diagrammatic, probably was intended for a sclerotium". If this drawing (figure 9) is considered along with Reinke and Berthold's own description of it, we fail to see how it can be considered either a true "sclerotium" or a pseudo-sclerotium of the budding type where longitudinal walls are formed, such as is found in other forms of Verticillium (*V. Dahliae* Kleb.). Reinke and Berthold clearly state that their "Dauermycelien" or "Sklerotien" are formed by the close lying together of darkened hyphae, and that no longitudinal walls or tissue bodies are formed. A study of their draw-

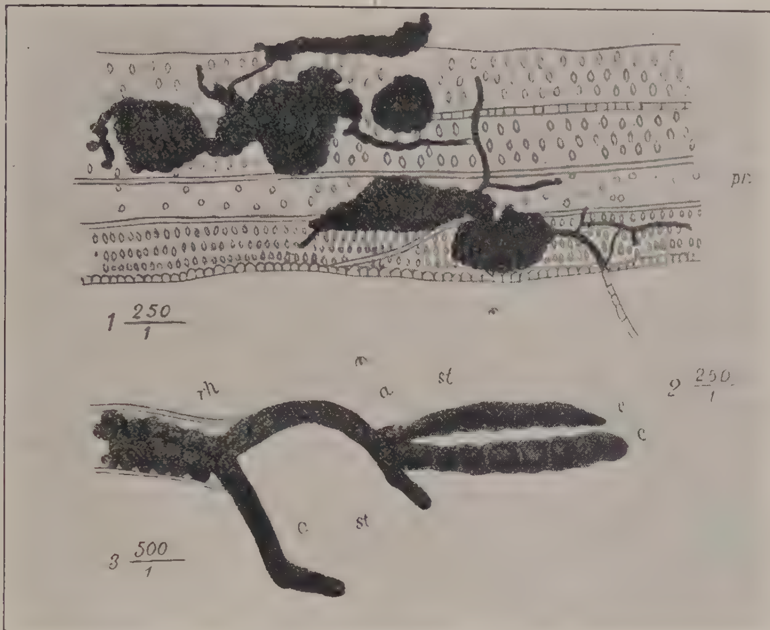

Figure 10. Photographic reproduction of Hallier's sclerotia-like bodies described as (1) 'conidienhaufen im Stengelgewebe der Kartoffel gezeichnet mit System D': (3) Conidia septata; System F. (After Rudolph).

ing indicates that their description and drawings agree. No mono-hyphal, pseudo-sclerotia such as are found in *V. Dahliae* were apparently observed by them. This, then, must be accepted that the so-called "sclerotia" of *V. albo-atrum* do not form a continuous tissue of cells such as is found in *V. Dahliae,* but are rather, as Reinke and Berthold state, a "lying together of darkened hyphae" and hence should be considered as "resting mycelium".

Rudolph further says that "if the structures drawn by Reinke and Berthold leave doubt as to their identity, certainly those drawn by Hallier (*10*) do not" (figure 10). He then goes on to describe Hallier's drawings and further says that "Reinke and Berthold reviewing Hallier's work expressed the belief that, in part, these structures were the 'black-brown Dauermycelium of Verticillium' and not to be confused with Pleospora".

It is true that the illustration given by Hallier is without doubt a "sclerotium" (pseudo-sclerotium) (figure 10). Rudolph, therefore, argues that Reinke and Berthold were perfectly familiar with "sclerotia" as such and since Reinke and Berthold expressed the belief that the structures of Hallier's were in part the "black-brown Dauermycelium" of Verticillium, that *V. albo-atrum* is a sclerotial fungus.

We would like to point out, however, that Hallier's drawings bear no resemblance to Reinke and Berthold's own drawings for *V. albo-atrum* (compare figures 9 and 10). If we accept Reinke and Berthold's own statement that "longitudinal walls were never seen in the Dauermycelien of *V. albo-atrum*" and that no tissue-bodies were formed, how can we accept

Hallier's drawing as being a similar body, when it contains numerous longitudinal walls, and appears as a tissue-like pseudo-sclerotium.

An explanation for the apparent discrepancy here is found in Rudolph's own statement—namely, that "Reinke and Berthold probably did not devote a great deal of thought or study to the way the sclerotia of *V. albo-atrum* are formed". If they did not give this much study, and their lack of detail of description and drawings of the resting condition leaves very little room for doubt on this question, it seems quite possible that Reinke and Berthold might under the circumstances not have appreciated the difference between the two structures. In any case, it seems to us that the important consideration here is that Hallier's "microsclerotium" (pseudo-sclerotium) does not agree with Reinke and Berthold's description or drawings of the "Dauermycelium" of *V. albo-atrum* and therefore little value is to be placed on Reinke and Berthold's opinion that Hallier's structures were *in part* the sclerotia of *V. albo-atrum.*

Rudolph further says, "Klebahn made the difference of sclerotia production between the two forms the great basis of distinction. To me even this distinction is not an important one in view of my experience with the strains in culture. Cultures of *V. albo-atrum* and *V. Dahliae* secured from Centraalbureau voor Schimmelcultures at Baarn, Holland, when first cultivated on Czapeck's synthetic nutrient agar were morphologically quite indistinguishable. *Both produced an abundance of microsclerotia*".*

He then goes on to say that Föex (*8*) also received from the Centraalbureau voor Schimmelcultures a culture of *V. albo-atrum* which likewise produced "sclerotia" (pseudo-sclerotia). He then assumes from their experience "that the fungus issued by the Centraalbureau voor Schimmelcultures as *V. albo-atrum* R. & B., produces sclerotia and not merely long, swollen, blackened hyphae. By sclerotia Rudolph means our pseudo-sclerotia. This assumption, however is not correct because we have received three different cultures of *V. albo-atrum* from Centraalbureau voor Schimmelcultures and not one of these has yet produced a pseudo-sclerotium. The cultures we obtained from Centraalbureau were isolated by Van der Meer and Van der Veen respectively. In addition, we have isolated in Ontario two forms from potato and tomato respectively which agree with the cultures received from Holland in that they produce only darkened resting mycelium.

It seems to us that whether or not one gets a pseudo-sclerotium fungus for *V. albo-atrum* from the Centraalbureau, or any other institution for that matter, depends entirely upon the conception of the species held by the investigator who isolated the fungus. For instance, if the culture named *V. albo-atrum* had come originally from Wollenweber, the culture would undoubtedly have contained pseudo-sclerotia. If, on the other hand, it had been originally isolated by Van der Meer it would have contained only "resting mycelium". The fact therefore that Föex and Rudolph received a pseudo-sclerotium culture for *V. albo-atrum* from the Centraalbureau does not mean that all cultures sent out by this institution as *V. albo-atrum* produce pseudo-sclerotia

* Italics are ours.

and that the Centraalbureau therefore consider V. albo-atrum to produce pseudo-sclerotia.*

Rudolph's second reason for not considering the difference in type of resting condition of value as a basis of distinction was based on his experience with the strains in culture. He says "that with continued cultivation on artificial media these strains have largely lost their ability to produce black mycelium and sclerotia", and in another place "after considerable cultivation on this same medium both forms largely have lost their ability to form these structures (carbonized hyphæ and microsclerotia). In this respect both forms remain constant culturally".

As pointed out previously this has to a certain extent also been our experience. We have found, however, that the *V. Dahliae* forms tend to produce their pseudo-sclerotia much more steadily in culture than do the forms of *V. albo-atrum*, their resting mycelium. Also we have found that the inability to produce the respective resting condition is only temporary, because culturing on sterilized potato plugs has restored the resting condition of both fungi. If Rudolph had cultured his apparently white mycelial cultures on potato plugs he would most likely have duplicated our experience, and found that the resting condition was in this way restored, and the group to which a culture formerly belonged could be thus ascertained. At least, this has been our experience with every form tested to date.

Both Wollenweber and Rudolph largely base their contention that *V. albo-atrum* is a "sclerotial" fungus on Reinke and Berthold's statement "one may call these resting mycelia sclerotia, even though their cells do not form the larger tissue bodies, as is the case in formations usually designated as sclerotia"†

There is no question but that Reinke and Berthold loosely used the term "sclerotia" in referring to their "resting mycelium" but as we have already pointed out, they themselves were not quite satisfied with the use of this term to describe their "Dauermycelien" since they realized that the masses or heaps of "resting mycelium" as found in *V. albo-atrum* were not true "sclerotia" when they said "even though their cells form no larger tissue bodies, *as is the case with formations usually designated as sclerotia*".

It seems to us that both Wollenweber and Rudolph did not sufficiently consider Reinke and Berthold's further statements namely (1) "that the "Dauermycelien" or "Zellhaufen" are formed only by the close lying together of darkened hyphæ"; (2) "that no larger tissue bodies were formed"; and (3) "that no longitudinal walls were ever seen". These last three statements seem to us to definitely delete the possibility of mono-hyphal tissue pseudo-sclerotia, such as are found in *V. Dahliae*, being present in *V. albo-atrum*.

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* Since this paper was written, I am in receipt of a letter from Prof. J. Westerdijk to the effect that "by examining lately our cultures of *V. albo-atrum* it appears that most of them had micro-sclerotia and ought to be called *V. Dahliae* Kleb. From some drawings of some of the cultures which were lost, we know that these were very probably also *V. Dahliae*".

In commenting further about some of the strains Prof. Westerdijk says "the latter three strains were formerly called *V. albo-atrum*, but the presence of micro-sclerotia made it desirable to call them *V. Dahliae*."

This clearly shows that the Centraalbureau voor Schimmelcultures do not consider *V. albo-atrum* to produce sclerotia. It also gives a possible explanation for the pseudo-sclerotial cultures obtained by Rudolph and Föex.

† Man kann diese Dauermycelien sklerotien nennen, wenn auch ihre Zellen keinen grösseren Gewebekörper bilden, wie es bei den gewöhnlich als Sklerotien bezeichneten Bildungen der Fallist.

If, according to Reinke and Berthold, a "sclerotium" as they knew it in *V. albo-atrum* was formed by the close lying together of darkened torulose hyphae, how then can we consider their description to include a "sclerotium" (pseudo-sclerotium) that is not the result of many torulose hyphæ lying together but is rather the result of budding of a single hypha. To us the pseudo-sclerotia formation is so opposed to their description of *V. albo-atrum* that we take the attitude already established by Klebahn, Van der Meer and others, that forms with such a resting condition should be considered a separate species: *V. Dahliae* Kleb.

We take this attitude, not only because such a resting condition was not described by Reinke and Berthold for *V. albo-atrum*, but because we have today a Verticillium fungus that produces its resting condition in the identical way as described by Reinke and Berthold, namely, in masses of closely intertwined normal to specialized darkened hyphae and with no production of pseudo-sclerotia whatever.

We therefore contend that *V. albo-atrum* should be considered to produce specialized "resting mycelium" but not pseudo-sclerotia and that *V. Dahliae* should include definite pseudo-sclerotia.

In other words, we consider both the types under discussion worthy of specific rank because they are morphologically and physiologically different as has been brought out in our experimental work. We cannot accept the view upheld by Wollenweber and Rudolph namely, that *V. albo-atrum* is a "sclerotia" (pseudo-sclerotia) producing fungus and that the form which does not produce pseudo-sclerotia should be considered but a variety of it.

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THE "COINCIDENCE" AS MAJOR FACTOR IN AGRICULTURE

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The major problem confronting agricultural research scientists on this continent today is that of reducing cost of production by increasing average yields per acre. During recent years there has been a gradual shifting of research effort from concentration upon isolated problems to a recognition of the great need for this fundamental adjustment. This change in outlook has been largely due to the unusual pressure of competition in world markets which has demonstrated so conclusively the fact that agricultural profits are governed by the relation of costs of production to selling price and not by selling prices only. As long as a country maintains a self-sufficing isolation, low cost of production in agriculture is not vital; but immediately it becomes either an exporter or importer of food stuffs, cotton, wool, and other commodities, competition in production costs of other countries must be met. The recent economic upheavals affecting world agricultural markets have been largely responsible for the keen interest aroused in our own costs of production, and investigations have disclosed striking diversities in yields per acre and consequently in costs of producing individual crops.

The farmer producing 10 bushels of wheat per acre cannot successfully compete with his neighbor under similar cultural methods producing 50 bushels per acre, yet he must sell at the same price in the same markets. Everywhere in Canada in every crop, diversities as great or even greater than this are shown in yields per acre. It is significant that in spite of the amazing progress in genetics, in knowledge of plant diseases and insects and their control, in soil surveys, and increased used of fertilizers, during the last forty years average yields per acre have shown no appreciable increase in this country. On the other hand, the almost unlimited possibilities for increased production have been demonstrated continually by the phenomenal yields achieved both on experimental plots and on individual farms. What is the secret of this inconsistency between our accumulation of scientific knowledge in relation to agriculture and our lack of gain in average yields per acre? It is that we have concentrated upon isolated problems of genetics, insect and disease control, soil fertility or physiological response to individual stimuli, and have neglected to view all agents in their interactive relationship as individual plant environments.

To attain that delicate adjustment between plant and environment which will insure maximum productiveness, increased collaboration and coöperation must be effected between the various agricultural research units. For, although the research scientist must specialize, agriculture itself is not specialized, and geneticists, plant physiologists, pathologists, entomologists, soil physicists and chemists, and meteorologists, must all join forces for successful solution of this fundamental problem of adaptation of plants to environment.

The culmination of all agricultural research effort must be, first, the determination of the optimum conditions for growth of individual plants or varieties, and second, equally accurate determination of individual environ-

mental coincidences under which the agricultural industry must operate in any given area. While choice of crops and breeds of livestock, cultural methods and economic policies may differ in various countries and in various ages, the primary factor in profitable agriculture has always remained the same, namely successful plant growth. The manner of its marketing whether in the form of grain, livestock, cured meat, butter, eggs, cotton or wool, does not alter or lessen the dependence of all branches upon it.

Research has disclosed that it is not one or two environmental conditions which govern plant growth and crop yields, but a coincidence or combination of interactive factors, and that one factor cannot be considered irrespective of the others. There is a definite coincidence of these conditions under which every plant finds optimum environment and produces maximum yields. This coincidence may differ considerably for individual varieties of the same species of plant or animal. Variation in the environmental coincidences under which agriculture proceeds are just as numerous, and may be just as definitely defined, as are the ideal requirements of individual forms of life. Scientific crop adaptation for Ontario, therefore, must be founded on an accurate knowledge of environmental conditions present in the province, together with the same accurate knowledge of the optimum requirements of individual plant crops and types of livestock for maximum yields. A comparison of all this data and subsequent distribution of crops according to the principles thus disclosed is the only sound basis for a provincial agricultural policy.

The conditions governing plant growth such as soil, temperature, moisture, topography, intensity and duration of light, drainage, climate in all its ramifications, altitude, mineral stimulants in soil, and occurrence of diseases and insects, must be considered not only in the individual relation of each to the plant, but each in relation to every other contributing factor. It must be recognized that the physiological reaction of plant or animal to an individual stimulus or condition is modified in some degree by the presence of every other environmental factor. Agricultural research must determine to what extent the varying phases of these factors in successive periods of growth contribute to the final yield. The value of this fundamental work in Canada is increased by the very great diversity in occurrence and combinations of these factors within our national boundaries and even within individual provinces.

In Ontario, as in other parts of Canada, research scientists and extension services are coming more and more to realize the futility of blanket recommendation or general agricultural advice for an agricultural area as extensive and varied as our province. No one would dream of including all the countries of Europe in any recommendation for agricultural improvement. To be valuable, such data must be accurate and related to local conditions, yet we in Ontario, with latitude range almost as great as that of Europe, have assumed an agricultural unit where there is merely a political and economic unit. The great diversity of agricultural conditions in Ontario may be indicated by the following comparisons. In Essex county, the growing season starts about March 15th, with a short cool day. At this date the length of day is practically uniform throughout Ontario, but as the season advances the more northerly latitudes gain in length of day, until about the 21st of

June when there are about 17¾ hours of daylight in Ontario's most northern points, compared with about 14 in Essex at the same date.

In travelling north, however, we find that although the length of day increases, the opening of the growing season is delayed by snow above ground and frost beneath, long after growth is advanced in Southern Ontario. Consequently, by the time the soil is ready for seeding in Northern Ontario, the long warm days and short nights are also present. In Essex the growing season commences in March with a mean temperature of 43.6. In Haileybury, it rarely commences before the middle of May with a mean temperature during the first days of growth of nearly 55 degrees. During July the mean temperature of the Niagara District is 71.4 as compared with 61 degrees at Kapuskasing. Plant growth in the northern areas consequently proceeds from the moment of seeding under an entirely different coincidence of growing conditions from that present in Southern Ontario. The farther north or south you go, the greater this difference attributable to latitude alone, and in addition we have other and equally variable factors which are characteristic of individual regions. Variations in soil types, topography and ameliorating effects of large bodies of water are only a few of the factors distinguishing environmental coincidences within given latitudes.

In Northern Ontario, plant growth is subject to the stimulating effects of long hours of daylight in conjunction with relatively high temperature throughout growing season. In many parts also the frost remains in the subsoil throughout the entire growing season. Consequently, plants or varieties which find their optimum condition in Essex could not be expected to grow as successfully under these northern conditions. This great variation in growing conditions is however, no indication that the North is inferior to southern counties for agricultural purposes. The success of agriculture in each district is dependent upon accurate determination of the crops and varieties best adapted to the peculiar characteristics of their growing seasons, for obviously with such variation in environment there would be equal variation in high-profit crops, in the diseases and pests attacking them, and in methods of control.

Thus we find corn, whose root system is very sensitive to cold bottom, thriving when planted in the warm soil of Essex some weeks after the beginning of the growing season and the disappearance of frost from the subsoil. In the North, however, even as far south as Sudbury, the frost may remain in the subsoil throughout the entire season with disastrous results to the root development of corn crops.

This does not mean that the environmental coincidence favourable for some varieties of corn cannot be found in the North. Corn may be grown on some well-drained, warm soils, with good exposure and a fortunate and unusual freedom from early frosts. One farmer whose land came under the observation of our research staff in the Sudbury District had just such conditions and in several seasons was successful in harvesting matured corn before the first frosts. As this is a dairy district and one of the major problems is the production of a silage crop as a substitute for corn, this farmer's successful crop was noted by neighbors and many experiments followed. But these farmers, not knowing accurately the conditions contributing to success,

wasted much time, land, and labor in efforts to raise corn as a silage crop. The successful farmer did not know himself all the reasons for his success and consequently could not help his neighbors who may have planted on land with cold soil, a different subsoil, poor drainage, acid reaction, or some more or less obscure adverse condition. Length of day also has marked influence on development of corn—and we find that corn for fodder finds optimum conditions in the length of day at Ottawa, while seed corn which requires short day for best development of seed finds ideal length of day in Essex.

Unlike corn,—oats, rye, peas, barley and wheat, whose root developments are stimulated by the cold subsoil and whose vital processes find in the long daylight their optimum growth requirement, are unusually successful in Northern Ontario. The potato, another crop which finds its optimum coincidence in long daylight, cool temperature, cool sandy soil, and plenty of moisture during growing season, produces large average yields throughout many districts of Northern Ontario.

In the case of Native flora, it is a comparatively simple matter to determine optimum requirement for mere survival through a comparative study of ecological conditions. But with cultivated flora and plant crops grown under artificial conditions and with variations in species developed for equally various purposes, it is much more difficult to determine the coincidence which will insure maximum yields at reasonable costs of production. A study of natural habitat discloses only the optimum coincidence for survival and conversely the conditions most unfavorable for development of disease and parasites. Increased yields however, are largely dependent upon modification of this survival coincidence to stimulate the type of growth required, and unfortunately the conditions most favorably to this particular type of growth may also be most favorable for development of diseases and insects. As the ultimate success of agriculture is guaged not only by successful yields but by the profits accruing from these yields, the economic factor or cost of production in relation to selling prices must always be a dominant factor in the determination of any agricultural policy. The problem of the agronomists and plant physiologists, therefore, is to determine that delicate adjustment of interacting factors which will produce maximum yields in individual crops and varieties at reasonable profits considering tillage, conservation of fertility, control of diseases and insects, etc. The factors controlling growth are so numerous, so interrelated, and the optimum requirements of each plant so modified by slight variations in breeding that their accurate determination requires much study and observation.

We find, for instance, that individual varieties of the same species differ considerably in their response to light stimulus and that this fact must be considered when selecting varieties for various latitudes. One variety of strawberry, when limited to a short day, may remain dormant indefinitely. By increasing the hours of daylight, either artificially or by change of latitude or altitude, the same variety will mature normally and bear fruit. Not only that, but predaceous insects which live on this plant may also remain dormant under the short periods of daylight and resume activity when the required stimulus is furnished in increased duration of exposure to light. Other varieties of strawberries, on the other hand, which are more sensitive to light find sufficient stimulation in the short day to produce bloom and fruit.

The duration of exposure to sunlight and variation in intensity have been discovered to have a marked influence on storage of carbohydrates in plants. Sunflowers for instance grown in full sun have been found to contain four times as many calories as plants grown under otherwise similar conditions, except exposure to light. Consequently, in districts of long or intense daylight, potatoes develop large and numerous tubers owing to their ability to increase storage of carbohydrates under these conditions. In some areas of high altitudes and cloudless skies the same storage may be accomplished in shorter duration of exposure. In British Columbia we find districts which produce phenomenal yields of potatoes, as would be expected from the research into optimum potato coincidences. Invermere for instance has cloudless skies, long day, ideal mean temperature during growing season (59.8°F.) combined with proper soil conditions. Recognition of the difference in response to light stimulus shown by different varieties is also most important in selecting varieties of certain crops to mature rapidly for early markets.

A comparison of yields of the same variety, under different coincidences and of different varieties under similar coincidences, provides the basis for many valuable conclusions. By comparing the average yields of a county or province with those of smaller individual areas it is at once apparent that there are certain sections which are peculiarly favorable for given crops, and exceed the average and all other individual sections in productivity. By determination of the various factors contributing to the optimum coincidence and by determining their interactive relationship by interrelation of research, the problems of super-productivity are solved.

In this problem of crop adaptation, it must be borne in mind that the important factors, from an ecological standpoint, are those not controlled by man, such as latitude, altitude, temperature, structure of soil, and topography. The presence of food in the soil, hygienic conditions and chemical reaction may be largely controlled by man if economically expedient, but the other conditions—light, temperature, structure of soil, height of water table, wind, etc., which control so largely the conversion of nutrients into the proper form to suit the varying needs of individual plants cannot be controlled.

We may find, for instance, that in many sections naturally favorable for a certain type of crop, the yields are much smaller than those in other individual regions of less favorable natural conditions, where improved methods of cultivation, scientific control of diseases and pests, and applications of fertilizers and plant stimulants have been used. But, given similar procedure, yields would always be higher and the cost of production lower in the area where natural conditions most closely approached the optimum requirements of the plant.

For example, the average yield of potatoes in Pennsylvania is 130 bushels, while that of the Sudbury district is approximately 190 bushels, yet under improved methods of culture, Pennsylvania has hundreds of acres producing over 400 bushels per acre. The record yield under this improved culture in Pennsylvania is 688 bushels, while in New Liskeard we have yields recorded 617½ bushels at a smaller cost of production. Given such methods as those employed in Pennsylvania, the Sudbury district could produce much larger average yields. On the other hand, the methods used in Pennsylvania

are too costly per acre to warrant their adoption under many of the growing coincidences devoted to potatoes in Southern Ontario. Last year the Colorado competition in potato yields per acre was won by a Colorado farmer with the enormous yield of 1145.17 bushels per acre. As the average yield in Colorado is only 133 bushels per acre, or less than that in Northern Ontario, this record yield indicates how far we are from exhausting the possibilities of our own favorable conditions. It also indicates the futility of the attempt of any given region to compete in national or international markets with any crop which does not find within that region favorable conditions.

I have used for illustrative purposes the marked differences between growing coincidences in Northern and Southern Ontario due to variations in daylight and climatic conditions; but there are many other equally important factors modifying plant growth which are extremely variable throughout all sections of the Province and cause marked differentiation in types of native flora within very limited areas. Differences in topography alone may necessitate absolutely different types of farming in two districts of otherwise similar characteristics, and differences in soil within either one of these districts will cause further variation. For instance, below the Niagara escarpment tender fruits flourish, while a mile south on top of the escarpment under similar light and soil conditions tender fruits are unprofitable. Moreover, below the escarpment the marked variations in types and depths of soils results in equally marked differences in types of tender fruits grown successfully.

It is interesting to note that a few inches difference in the height of the water table in adjoining fields of otherwise similar conditions will completely change the value of land for certain crops. Timothy, which requires deep root development, might flourish in one field but in the other with higher water table it could not develop normally, although alsike clover with its shallow-spreading roots would be successful.

Sometimes similar growth conditions may be present in two coincidences which, to the layman, may appear totally dissimilar. For example, we find the optimum coincidence for white cedar both on the shallow, well-drained, rocky soils and in deep impenetrable swamps where the water table reaches within a few inches of the surface. The reason for this is found, of course, in the type of root system of the cedar which is composed of masses of threadlike fibres developing horizontally but not in depth. Thus, other conditions being favorable, shallow soil is suitable however formed. In the swamp the water table forms as impenetratable a barrier to deep root development as does the underlying rock of the shallow soil. For most plants the height of water table marks the extreme possibilities of depth in root development.

The significance of this interrelation of factors in governing plant activities is indicated in the following illustration: Most plants are more or less susceptible to the action of SO_2 when it is present in the air. This action varies under different circumstances from the merest bleaching of tips of leaves to complete destruction of the entire plant. Research on this subject showed that SO_2 bleaching takes place only under a favorable coincidence of conditions, namely:

1. Daylight.
2. Sufficient density of gas.

3. Relatively high humidity.
4. Growing temperature.
5. Constant wind for a definite period, relative to density.

The intensity of the bleach is governed by:

1. Density of gas.
2. Duration of constant wind.
3. Susceptibility of the plant.
4. Age of the plant.

Further research, founded on the above facts, provided accurate data for the preparation of charts showing:

1. Comparative susceptibility of various plants.
2. Comparative susceptibility of plants at various stages of growth.
3. The economic aspect of bleaching at different stages of growth.
4. Rate of diffusion of gas after leaving stack.
5. Effect of wind velocity upon diffusion.
6. The ratio of gas intensity in proportion to the length of time wind remains constant.

Consequently, with the map of any so-called SO_2 zone before one on which are marked the various farms with individual crops and approximate date of planting, forest distribution, topography, and air currents; and with meteorological data, stack analysis and other charts available, it is possible to sit in an office and chart *accurately* the extent and intensity of any SO_2 bleach before ever going into the field. With accurate data available, it is possible in this way to calculate accurately the economic effect of SO_2 on every type of crop and forest growth in all sections of the zone. But, by overlooking one contributing factor, such a system would be rendered worthless. For instance, the stage of development of plants is very important in calculating susceptibility, and varies with individual crops. One field may be badly bleached while beside it one of the same crop planted a few days earlier and suffering the same exposure to SO_2 may be only slightly affected. The success of such a system of research, operating over a course of years proves that the behavior of living forms under definite conditions can be successfully charted and permanent policies based upon this knowledge. Other industries are making use of such means of eliminating hazard and only by the adoption of similar methods may agriculture hope to attain equal efficiency.

The immunity of plants to disease or injury under certain coincidences of conditions, is a problem upon which much research is being done at the present time. The possibilities for valuable discoveries along these lines are indicated by the recent work on wheat rust in which it was discovered that varieties of wheat which opened their stomata later in the morning than other varieties were less susceptible to the ravages of this parasite. This relative immunity was due to the fact that the optimum coincidence for the development of wheat-rust spores includes moisture and daylight, and those varieties which did not become active until the dew had dried, were vastly reducing the possibilities for the occurrence of this ideal coincidence. Thus, not only does

every plant have a definite combination of conditions under which it thrives best, but every disease and pest of plant and animal also has a definite coincidence under which it will occur and develop most rapidly. Conversely, there are certain coincidences which will prove most inimical to all these activities.

To illustrate further—there is a very definite relation between length of daylight, temperature, moisture, and the occurrence of certain pathological diseases of oats very prevalent in Northern Ontario. The long days and relatively high temperatures of the short growing season of the north, when accompanied by unusual moisture, result in a forced growth which is very susceptible to bacterial attack. In areas of poor drainage and poor air circulation, these diseases appeared every year on almost the same day—the peak of the growing season—that is, the greatest length of day accompanied by the highest temperature. By observation we were able to determine the ideal conditions for the development of these diseases and to institute research in control. We could not change the length of day or temperature, and in many cases, owing to the topography, drainage could be little improved; but after many experiments we were able to introduce varieties of oats less susceptible to the stimuli of the long day and high temperature. These varieties did not produce the lush growth of the original varieties and were consequently less susceptible to bacterial injuries. These diseases are not common in Southern Ontario, but the varieties found to have greatest immunity in Northern Ontario were not the varieties most productive and free from diseases in Southern Ontario.

The most successful plants, ecologically, are not necessarily the most profitable financially for any given region. Economy of production and marketing possibilities must be considered in conjunction when planning crop distribution. It is obvious that a plant which is not adapted ecologically cannot compete with the production of the same plant when grown under favorable conditions, and cannot, therefore, be financially profitable in the same market. But in the diversity of our growing conditions and in the diversity of the requirements of individual plants throughout the world lie our greatest possibilities for efficient crop distribution.

The working of this law of crop adaptation and the possibilities of maximum production under definite conditions is evidenced in study of comparative potato yields.

YIELDS OF POTATOES

In Canada,	the average yield is	150.6	bushels
" New Brunswick	" " "	188.3	"
" Ontario	" " "	113.3	"
" Quebec	" " "	162.6	"
" Saskatchewan	" " "	145.3	"
" British Columbia	" " "	183	"
" Northern Ontario	" " "	190.5	"

There is marked increase in production in proportion to increase in latitude and altitude. This is obvious in Ontario which has the low Provincial average of 113 bushels, in spite of the excellent yields in Sudbury, Rainy

River, Kenora, and other northern districts. The comparatively small acreage in potatoes in the North is responsible for the low Provincial average.

As noted above, however, no modifying factor must be overlooked in seeking to determine the ideal coincidence responsible for individual high yields. It must not be supposed, for instance, that the favorable light and climatic conditions of Northern Ontario will offset other unfavorable ones. The coincidence must be complete to be valuable for either practical or comparative purposes. With all other conditions ideal for potatoes, unsuitable soil or poor drainage is fatal; and in spite of the generally more favorable conditions, we have observed greater diversity in yields within limited areas in the Sudbury district than in the generally less favorable regions of Southern Ontario.

The fact that Ontario's average yield is low does not indicate that Ontario as a Province cannot compete in potato production with New Brunswick or British Columbia. It simply means that, as a Province, we are producing inefficiently.

There are very few types of agricultural conditions in Ontario which, when studied scientifically, do not hold possibilities for some type of profitable farming, but the necessary transitions must be based on accurate knowledge of possibilities and limitations and not be left to the uncertainty of individual experiments, neither must it be assumed that the suitable crop must already be growing in this country. One of the greatest values of such research is that it provide for the introduction of suitable varieties of plants, regardless of where they may be found. Also, knowing the exact conditions of any of our own regions which presents a problem in adaptation, measures may be taken to compare it with similar regions elsewhere and successful introductions of new varieties accomplished on this accurate basis.

The old trial and error method of crop adaptation may in the course of time evolve the same system of crop distribution which scientific research may accomplish in a fraction of the time. But at what cost of time and effort and consequent inefficiency from the national as well as the individual standpoint! Comparisons of the optimum coincidences for individual crops or types of farming with the environments in individual areas where these crops form the basis of a successful agriculture, show that generally speaking the trial and error method will eventually demonstrate the same conclusions as the law of coincidence.

For instance, comparison of the favourable conditions for growth of corn for fodder with the environmental coincidences present in various parts of Ontario indicates that the light, temperature, moisture in combination with certain types of soil present in the Eastern counties of Ontario fulfill the necessary requirements. A survey of this region shows that experience has already established a successful dairy industry throughout this district. But unfortunately certain soils in this area will not grow corn profitably—notably the podsol type which is very common, while the stony madrid proves ideal. In spite of the fact that dairy farming has been practised in this region for centuries and successful dairying is dependent upon a good fodder crop at minimum cost of production, corn is still being grown upon podsol soil and the stony madrid often devoted to less profitable crops.

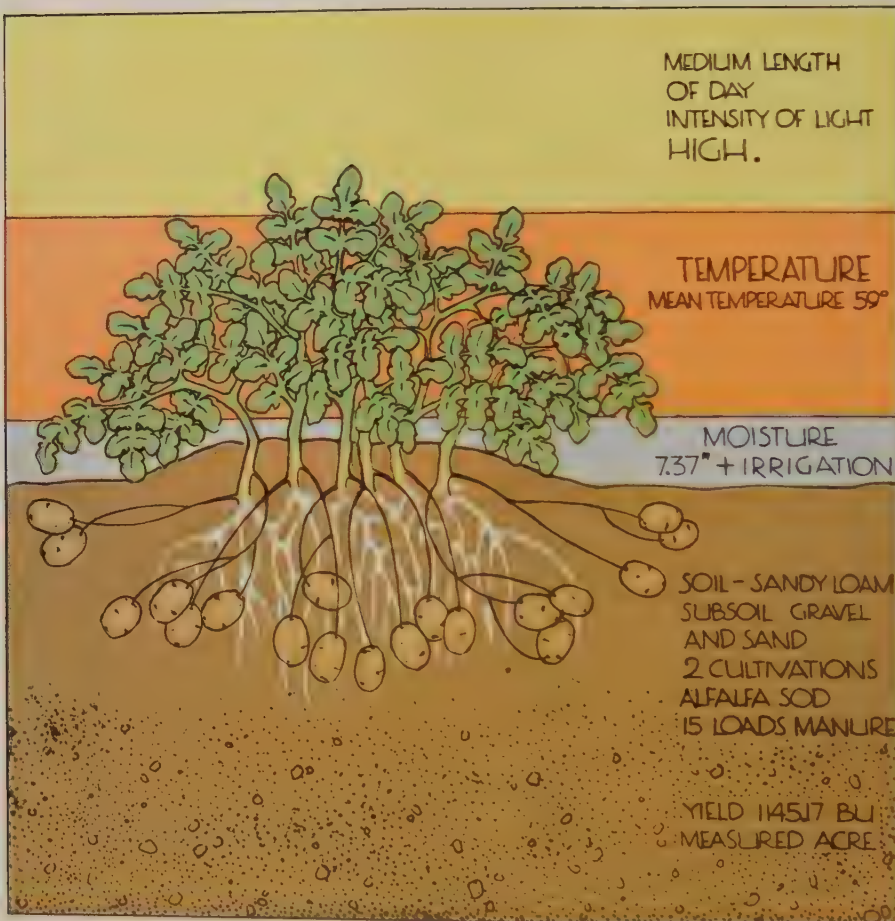


Figure 1. Tuberization coincidence. Favourable conditions for tuber development—light, temperature, moisture and soil conditions which have produced record yields in United States. (1145.17 bu. per measured acre on the farm of L. G. Shutte, Colorado.)

Neither does the adoption of an accurate system of crop adptation mean the cultivation of one crop to the exclusion of all others. It means concentration on those crops offering profits, and the exclusion of those which comparisons of conditions present, and conditions required by the plant show they could never be profitably grown. Equal diversification may be maintained to suit the variety of conditions present on every farm, but efficiency is increased by scientific distribution.

One of the most potent contributions to the existing unsatisfactory situation in Western Canada from production standpoint is the fact that much land has been settled for wheat-growing purposes where climatic hazards are so great as to prohibit profitable production over a course of years. Since the introduction of mammoth machinery, delivered with little down payment, much of this submarginal land which could not be cultivated under old methods has been included in our wheat producing acreage and is largely responsible for low average yields. Fore-handed research into growing conditions reveals the undue hazard which cultivation of such regions under any circumstances involves. There has not been sufficient differentiation between good wheat land and land which might only occasionally have the right coincidence to produce a profitable yield. Moreover, no effort was made to differentiate between land suitable for wheat only—and there is much of this—and that on which the less hazardous diversified farming might be profitably introduced.

Comparison of coincidences yielding potato tuber records.

	Monte Vista, Colorado	Invermere, B. Columbia	New Liskeard, Ontario
Latitude	38 N.	50.30 N.	48 N.
Altitude	7,600′	2,740′	639′
Length of day	Medium	Long	Long
Intensity of light	High	Medium	Low
Topography	Level	Level	Level
Moisture	7.37″ + irrigation	3.35″ + 8″ irrigation	12″. No irrigation
Temperature	Mean for growing season 59° F.	Mean for growing season 59.6° F.	Mean for growing season 61.5° F.
Wind velocity	5 miles average		7.5 miles average
Soil structure	Sandy loam gravel and sand subsoil	Fine Silty Loam on gravelly hardpan.	Clay loam and clay subsoil
Drainage	Excellent	Excellent	Good
Height of water table	High		High
Reaction	Alkaline	Alkaline	Alkaline
Fertilizer applied	15 loads well rotted manure	20 tons well rotten manure.	15 loads well rotted manure
Variety	Brown Beauty	Gold Coin	Pioneer Pride
Seed—size	5″	2 to 3″	
quality	Certified	Certified	
quantity	47 bu. to acre		18 bu. to acre
Diseases present	Rhizoctonia, black-leg and scab	Rhizoctonia, scab, mosaic	Rhizoctonia, scab
Crop previous year	Alfalfa		Clover
Length of growing season	May 15th to Sept. 7th —Frozen on Sept. 7	May 22nd to Sept. 28	May 25th to Oct. 3rd

Marketing, labor conditions, land values, and transportation facilities, must all play their part in further modifying crop selection, just as cultural methods, fertilizers, liming and drainage will play equally important parts in

increasing yields. But all these aids to success are effective and economically sound as government or private measures, only when applied on a solid foundation of scientific crop distribution throughout the province based on recognition of the law of coincidence in environmental factors.

BOOK REVIEW

THE SOIL AND THE MICROBE, by Selman A. Waksman and Robert L. Starkey. (John Wiley and Sons, Inc., New York and Chapman & Hall, Ltd., London, 1931. Pp. 260, Fig. 85, Price $3.50).

"The Soil and the Microbe" is suitable for a lecture course in general soil microbiology. It is shorter and better adapted to the undergraduate students' needs than Waksman's "Principles of Soil Microbiology"; the latter contains a large number of references, and is, for this reason, particularly valuable as a reference book, whereas the former contains a comparatively small number of selected references at the close of each chapter.

The material, including illustrations, of which the book under review is composed, is drawn from many sources. Much attention is given to soil microörganisms other than bacteria, as the great importance in soil economy of these other organisms is now realized. Most of the chapters are summarized, and this is a useful feature of the book.

The introductory chapter contains a short discussion of the nature of soil, the rôle of microbes in plant growth, the nature and absorption of plant nutrients. In Chapters II and III the forms, abundance, and activities of soil bacteria, fungi, actinomyces, algae, protozoa, worms and insects are considered briefly, and methods of studying these organisms, including the direct method, are discussed.

A noteworthy feature is the attention given in Chapter IV to the rôle of soil microbes in the decomposition of non-nitrogenous organic compounds. There was a tendency in earlier text books on agricultural or soil microbiology to devote much less attention to the non-nitrogenous compounds than to the nitrogen compounds, for the simple reason that the soil nitrogen compounds had been studied more extensively. In the two following chapters the more familiar transformations of nitrogen compounds, and microbes responsible for these changes, are discussed, and considerable attention is given to the activities of non-symbiotic nitrogen-fixing bacteria.

The transformations of mineral substances in soil through the direct or indirect action of microbes are dealt with in Chapter VII, and more than usual attention is given to formation of acids by microbes and their solvent effects. Interrelationships between higher plants and soil microbes are considered in Chapter VIII, and attention is given to carbon dioxide relationships, the influence of root excretions, and the associative growth of green plants and microbes.

Chapter IX deals mainly with modification of the soil population as effected by a variety of soil treatments, and micro-biological methods of determining soil fertility are discussed. The concluding chapter reviews the general importance of microbes in soil fertility.

Waksman and Starkey have performed a valuable service in bring together and condensing much scattered information for the benefit of students of soil microbiology and biochemistry.

J. D. N.

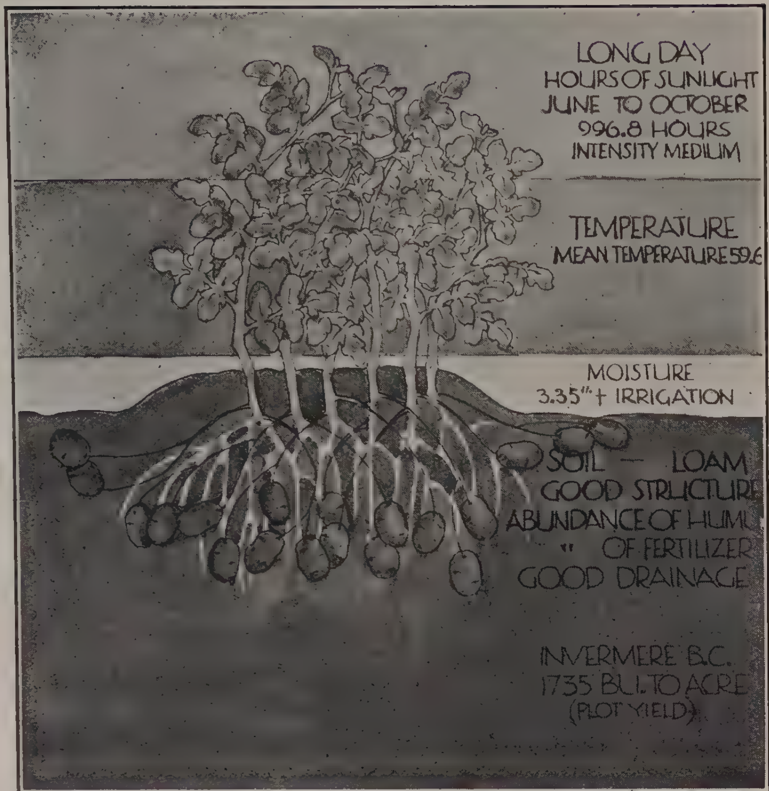


Figure 2. Coincidence producing record yield for British Columbia. Plot yield at Invermere 1735 bu. per acre. Compared with the Colorado coincidence we find that the longer day in British Columbia compensates for the greater intensity of light at the higher altitude in Colorado. Temperature, moisture and soil conditions are approximately the same.

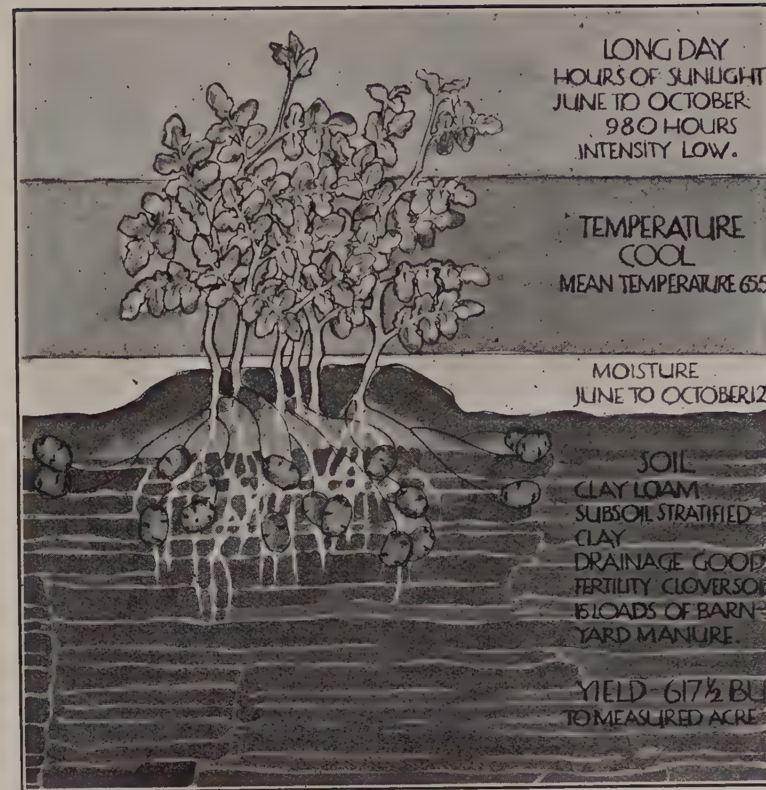


Figure 3. Tuberization coincidence. Northern Ontario. Long day, cool temperature, abundant moisture and favourable soil resulting in a yield of 617-½ bu. per measured acre on farm of Chas. Thomas, New Liskeard.

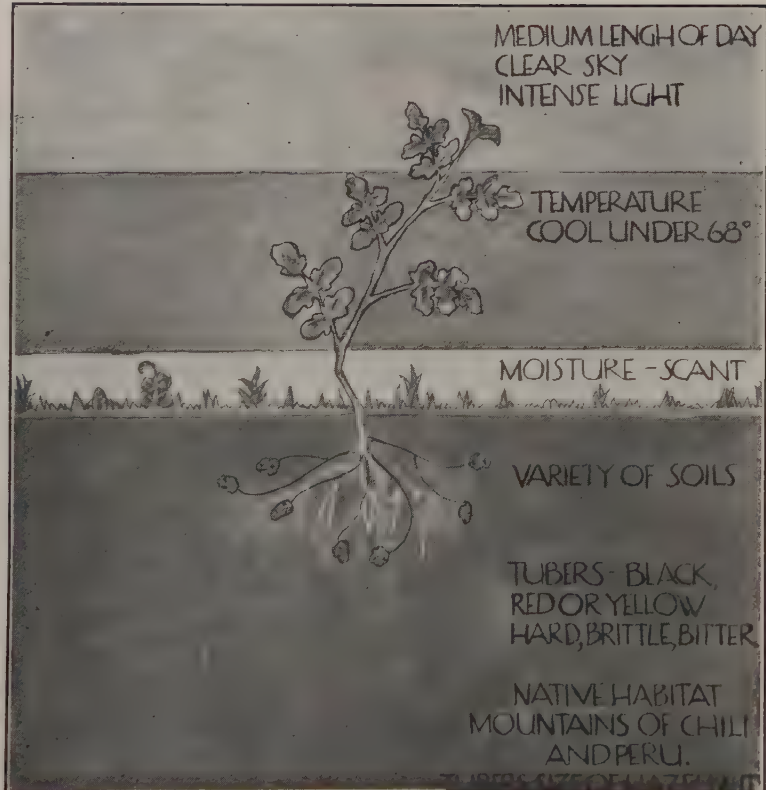


Figure 4. Survival coincidence. Optimum conditions for survival of plant due to unfavourable conditions for development of disease. Short day and lack of moisture however limit storage of carbohydrates in form of tubers which is the desired development for commercial purposes.

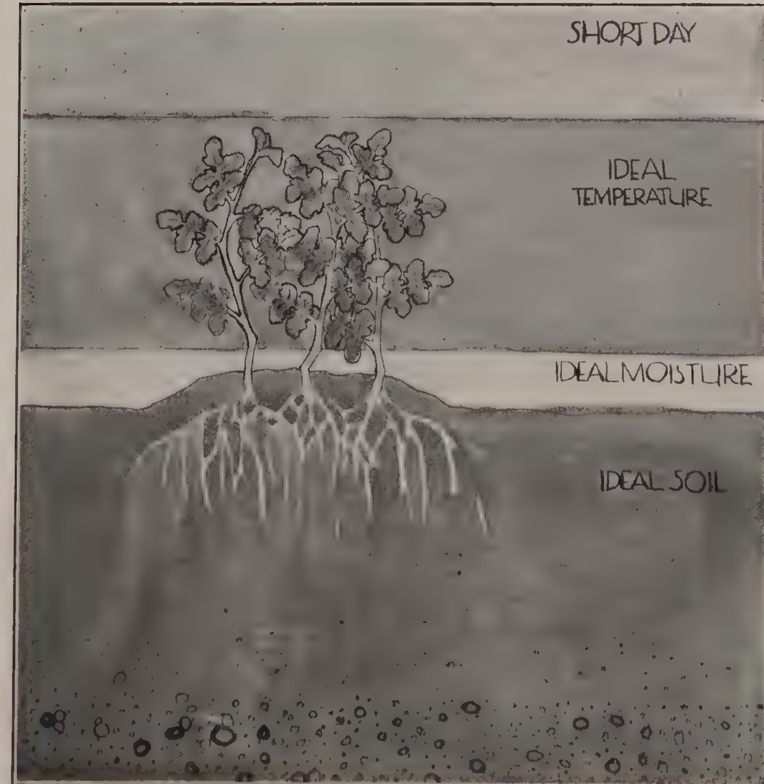


Figure 5. Non-tuberization coincidence. In spite of other favourable conditions, the too short day prevents storage of carbohydrates and formation of tubers.

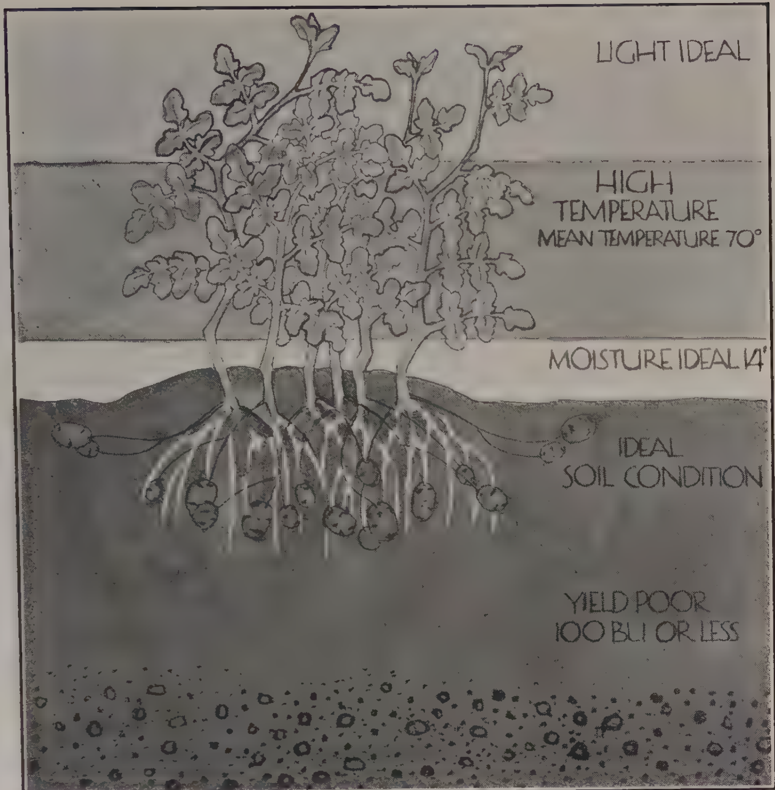
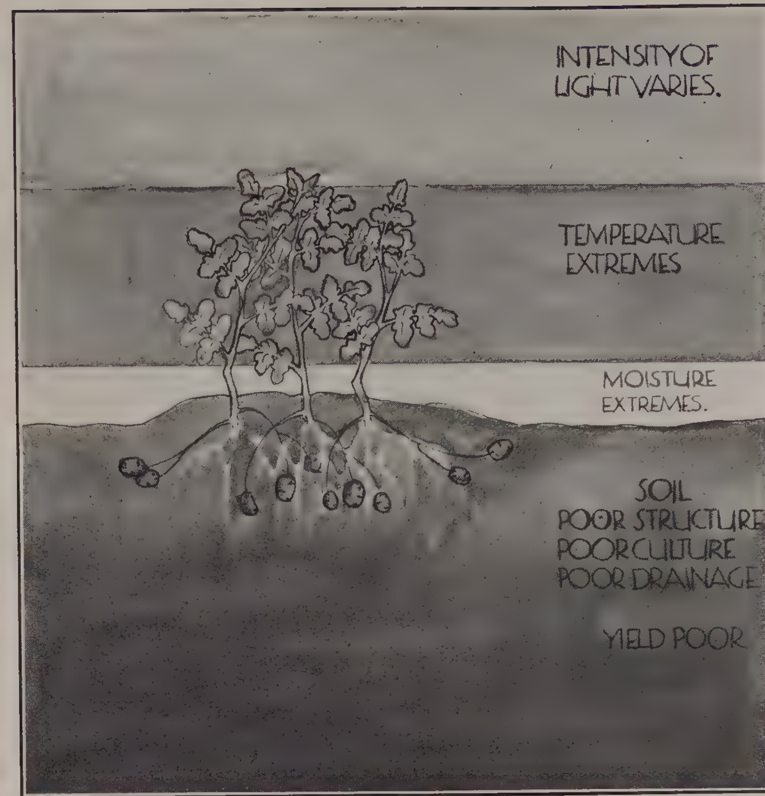


Figure 6. Leaf and stem coincidence. Favourable conditions for growth of leaf and stem. In spite of good soil, moisture and light conditions, high temperature checks storage of carbohydrate in the form of tubers.



7. Intermittent growth coincidence. Varying intensity of light, extremes in temperature, alternating excess and lack of moisture, poor drainage, anyone or more of these conditions present intermittently may cause cessation of growth until favourable conditions are restored. The result is a poor yield and consequent high cost of production.

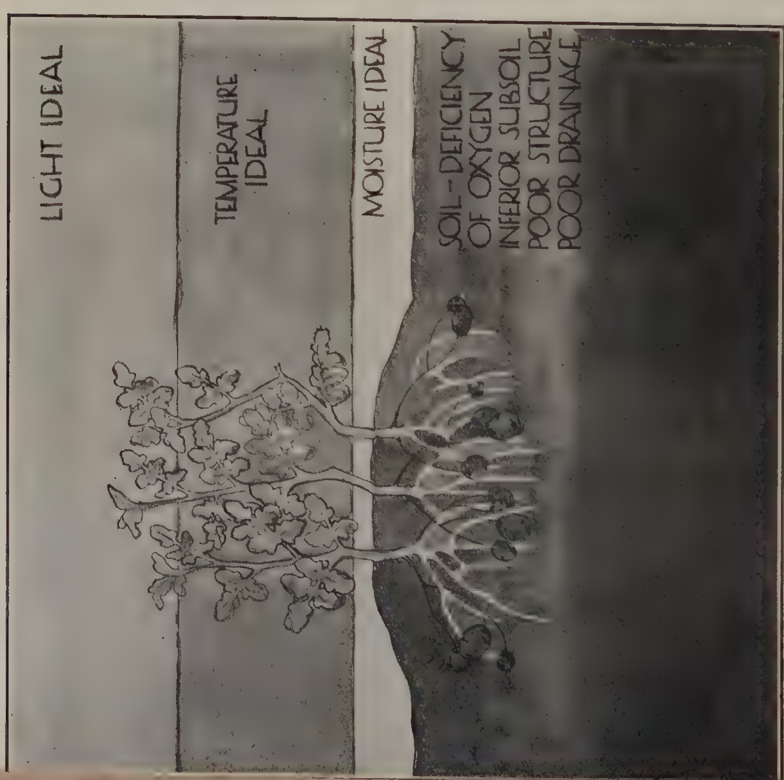


Figure 8. Coincidence conducive to disease. Light and temperature and precipitation favorable—but excess of moisture and lack of aeration due to poor soil conditions results in unhealthy tissues, susceptible to various diseases.

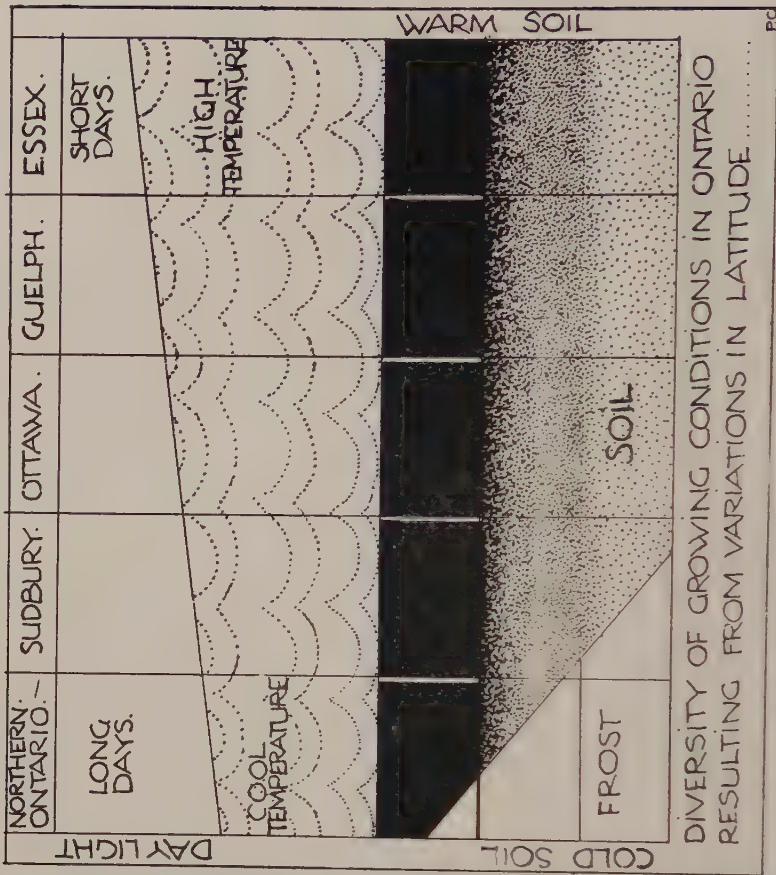


Figure 9. Diversity of growing conditions in Ontario resulting from variations in latitude.

THE FORMATION OF THE HEN'S EGG *

Part IV.†

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IV. ABNORMAL TYPES

Abnormal eggs of various types have been found and described from time to time. These types belong to four main classes which are apparently produced by different causes or, at least, different combinations of causes. The four main groups are as follows: (a) dwarf eggs; (b) multiple-yolked (double, triple and quadruple yolked eggs); (c) double eggs (eggs within eggs); (d) abnormally shaped (stalked) eggs. For convenience, each of these four groups may be considered separately.

a. Dwarf Eggs

1. *Review of the literature.* There are many cases on record in the literature of dwarf eggs. These have, according to Pearl and Curtis (1916) been called by various names such as "cock eggs", "luck eggs", and "witch eggs", according to their supposed origin or power for good or ill. Pearl and Curtis have reviewed the findings of earlier writers and have presented data on a fairly extensive series of dwarf eggs collected over a period of eight years at the Maine Agricultural Experiment Station.

Pearl and Curtis classify dwarf eggs according to shape into prolate-spheroidal and cylindrical, the latter being comparatively rare. Prolate-spheroidal dwarf eggs are comparatively broad, hence have a characteristically high index while the cylindrical eggs have, as would be expected, a lower index than most normal eggs. On the basis of contents, Pearl and Curtis found that 35.03 percent contained no yolk, 55.11 percent contained a membraneless fragment of yolk, whilst 9.85 percent contained a small yolk enclosed in a membrane. The eggs with little or no yolk were variable in size and significantly smaller than the eggs with a small yolk.

Most of the dwarf eggs were laid from March to July inclusive, which was also the period of highest egg production. The increase in the number of dwarf eggs was, however, greater than would be expected on the basis of increased egg production alone. It was further found that these eggs were not laid at any particular time with reference to the litter or the clutch which agrees with the findings of Warner and Kirkpatrick (1916).

With regard to the physiological conditions and the stimuli which lead to dwarf egg formation, Pearl and Curtis state that their data support an earlier statement made by Pearl, Surface and Curtis (1911), that there are three fundamental factors concerned, namely: 1. The bird must be in active laying condition; 2. There must be some stimulus to secretion such as a small yolk, a fraction of a yolk, hardened albumen or a blood clot; 3. It seems likely that ovulation must precede secretion around the mechanical

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stimulus. Since no evidence of ovulation could be found in a few cases and since albumen is a secretion of the oviduct it appears that only the first of these factors can be considered proven to be necessary.

2. *Observed Cases.* Several dwarf eggs were obtained from a number of different birds during the course of the present investigation but only those obtained from two birds are of sufficient interest to be described here. One of these two birds was a Light Sussex pullet that had been operated on and one inch of the albumen part removed. Forty-four days later a dwarf egg was found in her cage. This egg was small, weighing only 9.71 grams, while the shell weighed 1.27 grams (table 8). A small clot of blood surrounded by a little coagulated albumen had served as a yolk. The bird appeared to be in laying condition but no further eggs were obtained so she was killed 13 days later. The ovary was in active functional condition. The oviduct was restricted at the site of the operation. Anterior to this was a clot of blood enclosed in albumen, while posterior to it was an elongated and twisted "egg" consisting of albumen covered with shell membrane and some shell. This "egg" she had, apparently, been unable to expel.

The other bird was a Barred Plymouth Rock hen, No. 824 referred to above. This hen laid 7 dwarf eggs from March 3rd to 25th and 2 normal eggs. The data for these and two other eggs, one laid before the first, the other after the last dwarf egg was obtained, are presented in table 8. There was a blood clot surrounded by a little coagulated albumen in the eggs laid on March 3, 11, 19 and 22, with chalazæ-like material in the one laid on March 12. Nothing that could serve as a mechanical stimulus to secretion was found in the dwarf eggs laid on March 23 and 25.

Figure 8. Dwarf Egg Laid by Hen No. 824 on August 9th.

Another dwarf egg was obtained from No. 824 on August 9th, the first egg laid after a broody period and moult. This egg was, in shape, more nearly like normal eggs from this hen than the dwarf eggs previously laid, as will be seen by comparing the data in table 8 and figures 4 and 8. It contained a vitelline membrane almost free from yolk. No. 824 was killed three hours after laying this dwarf egg and yolk material found in the body cavity. There was a normal yolk with chalazæ and thick albumen in the middle of the albumen part.

TABLE 8.—*Data on dwarf eggs.*

Hen No.	Date Laid	Length	Breadth	Diff. in Breadth	Index	Wt. of Egg	Wt. of Yolk	Wt. of Albumen	Wt. of Shell
		mm.	mm.	mm.		gm.	gm.	gm.	gm.
1634	Dec. 26	33.99	22.28	.08	65.55	9.71	– –	8.44	1.27
824	Feb. 28	61.12	36.51	.11	59.73	44.86	17.02	24.54	3.30
"	Mar. 3	31.52	24.27	.03	77.01	10.76	– –	9.24	1.52
"	" 11	30.51	25.12	.07	82.34	11.00	– –	9.45	1.55
"	" 12	31.00	24.91	.04	80.35	11.08	– –	9.51	1.57
"	" 16	65.09	37.16	.16	57.08	48.30	18.62	26.93	2.75
"	" 19	32.75	26.27	.07	80.22	13.04	– –	11.23	1.81
"	" 20	61.09	36.42	.28	59.62	44.57	17.34	23.79	3.44
"	" 22	28.34	24.62	.05	86.88	9.75	– –	8.76	0.99
"	" 23	32.54	26.16	.03	80.40	13.05	– –	11.20	1.85
"	" 25	29.32	24.56	.06	82.36	10.42	– –	8.97	1.45
"	" 26	63.11	37.91	.29	60.07	49.22	17.09	28.88	3.25
"	" 9	51.07	28.29	.10	55.39	24.05	– –	21.77	2.28

The eggs usually laid by No. 824 were long and narrow like the 4 normal eggs for which data are given in table 8, (see also figure 4). The first 7 dwarf eggs, on the other hand, were comparatively wide as shown by the index, which averaged 82.37, compared with 59.12 for the four normal eggs. This agrees with the findings of Pearl and Curtis referred to above, that prolate-spheroidal eggs have an unusually high index.

The shells on the eggs laid by this hen were generally thin, hence weighed comparatively little. Thickness of the shell (and shell membrane) on the 4 normal eggs (table 8) was .18 mm., while the thickness of the shell of the 7 dwarf eggs was .27 mm., which is close to what may be considered the normal thickness of shell of about .30 mm.

The procedure for weighing yolks made it possible to check approximately the strength of the vitelline membrane. The yolks were dried on paper but weighed in beakers. If the vitelline membrane was weak, it would break when the yolk was rolled into the beaker. This happened a number of times when weighing the parts of eggs laid by No. 824 in March and April, which indicates that weakness of the vitelline membrane was one of the factors responsible for the dwarf eggs laid.

The data on the dwarf eggs from these two hens support the conclusions of Pearl and Curtis and others that dwarf egg production occurs only when the bird is in laying condition. Furthermore, they agree with their observation that a mechanical stimulus to secretion is usually enclosed in a dwarf egg. Finally, the evidence from No. 824 supports the findings of Pearl and Curtis that such eggs generally occur after ovulation. It appears very likely that such was the case since the first seven dwarf eggs were laid at about the same time that a normal egg would ordinarily have been laid, while the yolk material found in the body cavity after the last one was laid, and the vitelline membrane in this egg, point to such a conclusion. This would account for results observed here, but cases have been reported where it was doubtful whether ovulation had taken place. These cases would seem to indicate that the oviduct may be put in such a condition that secretion can be started by a mechanical stimulus although ovulation has not actually occurred. There is also some indication that secretion leading to the formation of an egg-like structure may start without ovulation and a mechanical stimulus, but all cases observed so far may be due to the yolk having started secretion before escaping into the body cavity. It, therefore, appears probable that nearly all dwarf eggs follow ovulation, the ovum, or most of it, passing into the body cavity.

b. *Multiple-yolked eggs*

1. *Review of the literature.* Three classes of multiple-yolked eggs, based on the number of yolks present, have been reported. These are double, triple and quadruple-yolked eggs. Double-yolked eggs are the commonest type of abnormal egg produced, while eggs with more than this number of yolks are quite rare. Curtis (1914a) states that most multiple-yolked eggs are produced at the beginning of the laying year. All of the triple-yolked eggs recorded by her were laid by hens less than six months old, while some double-yolked eggs were laid throughout the year.

Occasionally individuals are found that habitually lay double-yolked eggs. Parker (1906) cites three earlier writers who found such cases and another is recorded by Glaser (1913). These cases are apparently rare. It is of interest that Féré (1897b) claims to have obtained double-yolked eggs by drugging hens with atropine sulphate.

According to Curtis (1915a) there are three types of double-yolked eggs in addition to those where two yolks are enclosed within the same vitelline membrane: (1) Double-yolked eggs having the entire set of egg envelopes common to the two yolks; (2) Double-yolked eggs having all or part of the thick albumen common to the 2 yolks but with separate chalazal membranes; (3) Double-yolked eggs in which the yolks have separate chalazæ and thick albumen but a common shell membrane and shell. The second type comprised 70.3 percent of 118 reported on by Curtis.

According to Curtis, double-yolked eggs sometimes represent a heightened rate of fecundity and sometimes an abnormally low physiologic tone of the oviduct. Parker considered that most double-yolked eggs are the result of simultaneous ovulation but, as pointed out by Curtis (1915a), such eggs can seldom be explained in this way. Curtis found only one case of two small yolks within a single vitelline membrane while Glaser describes an interesting case of secondarily fused follicles in the ovary of a hen that had habitually laid double-yolked eggs and which he considers points to simultaneous ovulation. The more common cause of double-yolked eggs, according to Curtis, is an inactivation of the oviduct while the first yolk is still in the upper part of the oviduct, or antiperistalsis, which sends the first yolk back before it reaches the isthmus, resulting in eggs of type 3. This type is, therefore, closely related, causally, to some double eggs (eggs within eggs) to be considered later.

2. *Observed Cases.* A number of double-yolked eggs were collected from birds other than those used in the present investigation but for various reasons a complete record on the identity of envelopes was obtained for only 9 out of the 39 eggs obtained. Of these 9 eggs, 5 had all the membranes (chalazæ, thick albumen, shell membrane and shell) common to the 2 yolks, 3 had separate chalazæ and one separate chalazæ and thick albumen. Three of these 9 eggs were laid by one hen and 2 by another hen, while four other hens laid one each.

One case of special interest is that of No. 798. This bird was operated upon March 5th and a paraffin sphere weighing 2.1 grams and measuring about 16 mm. in diameter inserted through an incision made about the middle of the albumen part. The sphere was pushed 3 cm. back from the incision. This paraffin sphere was found in the cage 38 hours later surrounded by a small amount of thick albumen, shell membrane and a little shell. Thirteen days later this hen started laying again, the first egg laid being double-yolked, followed by 2-single-yolked eggs, another double-yolked egg two days later, followed on successive days by two single-yolked eggs and a double-yolked egg as shown in table 9. She laid 8 more single-yolked eggs up to and including April 11th, when she was again operated upon, but no more double-yolked eggs were obtained.

TABLE 9.—*Data on three double-yolked and five single-yolked eggs laid by hen No. 798.*

Date Laid	Length	Breadth	Diff. in Breadth	Index	Wt. of Egg	Wt. of Yolk	Wt. of Albumen	Wt. of Shell
	mm.	mm.	mm.		gm.	gm.	gm.	gm.
Mar. 20	68.45	44.17	.14	64.53	74.30	13.89 14.66	39.56	6.19
" 22	59.26	40.78	.19	68.81	55.02	16.51	32.74	5.77
" 23	54.29	41.14	.16	75.78	51.56	15.70	30.18	5.68
" 25	71.52	46.39	.25	64.86	85.22	15.34 17.36	45.54	6.98
" 26	56.36	40.29	.09	71.48	51.57	15.53	30.50	5.54
" 27	56.47	40.37	.06	71.49	51.90	14.02	31.92	5.96
" 28	70.10	46.17	.14	65.85	82.79	14.51 17.08	44.55	6.65
" 30	58.07	41.37	.22	71.25	55.84	16.03	33.79	6.02

The double-yolked eggs laid by this hen show the same relation to the single-yolked eggs noted by others (Curtis 1914a), namely, an increase in size with a proportionately greater increase in length than in breadth and hence a lower index. There is no increase in the difference in breadth (maximum and minimum diameter), thus agreeing with the correlation studies reported above (table 6), which showed that variation in the diameters of an egg is not influenced by its size.

The weight of the egg and its parts increased with the length and breadth. The yolk increased proportionately more in weight than the albumen and shell. As a result, the proportion of albumen and shell decreased, on the average, 6.34 and 2.72 percent respectively. These results agree with those obtained by Pearl (1910), but other evidence mentioned above shows that the relation is not so regular as indicated by the material on which Pearl and his co-workers based their conclusions.

The shells on the double-yolked eggs were thinner than the shells on the single-yolked eggs laid by No. 798. The thickness of shell (and shell membrane) on single-yolked eggs was .33 mm. in the equatorial region and .336 on the pointed end, while the corresponding thickness of shell for the double-yolked eggs was .29 and .24 mm. respectively. The reduction in thickness of shell on the double-yolked eggs was therefore greater on the ends than in the equatorial region, which agrees with the observations of Romanoff (1929).

Pearl and Curtis (1914) found that, in some cases, operations on the oviduct inactivated it so that the bird was unable to lay although there was no mechanical obstruction in the duct. Only one case was found in the course of the present investigation where the oviduct was open but unable to expel material after an operation made to alter some part of the duct. Later, however, cases occurred where the artificial "yolks" remained where placed although pushed away from the site of the incision made through the wall of the oviduct. In the case cited above, such an artificial yolk remained in

the oviduct 38 hours before it was expelled, without any secretion having apparently occurred. Some such process as this, by which the yolk is retained in the oviduct without secretion occurring, may be responsible for the laying of double-yolked eggs. The first two double-yolked eggs laid by No. 798 would, on this assumption, have been due to the retention of the first egg in the funnel region until the second yolk was expelled from its follicle, when both passed down the oviduct together. The third egg may have been produced in the same manner, although here, a heightened rate of ovulation is indicated, since eggs were laid on the three preceding days. Rapid ovulation may account for the laying of all these double-yolked eggs since at least 9 yolks were released from the ovary in as many days, whereas at other times the maximum apparent rate for this hen was two in three days. In any case antiperistalsis probably was not concerned since all the egg envelopes were common to the two yolks in these three double-yolked eggs.

c. *Double Eggs*

1. *Review of the literature.* No double eggs or eggs within eggs were observed during the course of the present investigation but some points in the production of these eggs are of special interest, hence may be briefly referred to here.

Eggs of this type are generally differentiated from multiple yolked eggs by one of the yolks having at least a shell membrane in addition to some albumen which separates it from the other yolk. This is a purely arbitrary distinction since double eggs and multiple-eggs as here described form a continuous series.

One of the more recent contributions to the literature on double eggs is that of Curtis (1916) who discussed the earlier reviews of Davaine (1861), Parker (1906), von Durski (1907), and the more recent papers of Patterson (1911) and Hargitt (1912). Recently Roberts and Card (1929) have described briefly an interesting case of two double eggs (weighing 171 and 164 grams respectively) laid by a pullet. These belonged to the first type of double egg described by Curtis (1916), who gives the following classification of the 16 eggs reported by her. (1) Double eggs in which the enclosing egg is complete and normal and (a) the enclosed egg is also normal, or (b) the enclosed egg is a dwarf egg; (2) double eggs in which the enclosing egg does not contain a yolk but is otherwise normal and encloses (a) a normal egg, or (b) a dwarf egg.

Parker (1906) came to the conclusion that double eggs result from anti-peristalsis but Curtis (1916) considers it possible that the return of the egg to the upper part of the oviduct may not be due to reversal of peristalsis. Whatever the process is, there is no longer any doubt that eggs may travel up the duct, in some cases finding their way into the body cavity (Pearl and Curtis, 1914; Curtis, 1915b), in others returning down the oviduct, when a double egg is the usual result. There is evidence that the enclosed egg is sometimes overtaken by the enclosing egg or that the enclosed egg does not move far up the oviduct before it is met by the enclosing egg (Parker, 1906). In only a few cases is there any evidence of secretion having occurred while the egg was travelling up the oviduct, which Curtis (1916) suggests may be due to the rapidity with which the eggs move or to the oviduct

being "polarized to such an extent that secretion is discharged only when the stimulus advances in the normal direction". In the case of the first "egg" from No. I 2398 referred to above, there was no evidence of secretion while it moved up the oviduct although it apparently moved quite slowly.

It is evident that double eggs may result from abnormal action of the oviduct only. This is mainly anti-peristalsis, which moves the egg up the oviduct, combined with other abnormalities such as those responsible for the production of dwarf eggs. Hence these eggs may, as pointed out by Parker, be the product of an abnormal oviduct or an abnormal oviduct and ovary, while doubleyolked eggs may, in certain cases, be the product of an abnormal ovary only.

One other point of interest in connection with these eggs should be mentioned, namely that the enclosed egg was, with very few exceptions, located in the pointed end of the enclosing egg. The exceptions are considered by Curtis to be due to the yolk of the enclosing egg passing the enclosed one in the oviduct. The pointed end of the enclosed egg was generally towards the pointed end of the enclosing egg, except where the enclosed eggs had apparently been reversed, which probably occurred in the uterus.

Since double eggs result mainly from abnormal functioning of the oviduct, experimental study of the factors concerned may be expected to produce valuable information with regard to its normal functioning. At present, practically nothing is known concerning the normal muscular activity of the hen's oviduct or its parts. There is good reason to believe that variations in muscular activity are responsible for the majority of abnormal eggs attributable to this organ.

d. *Abnormally shaped eggs*

1. *Review of the literature.* The eggs in this class are chiefly those that are composed of a normal shaped egg with a part (stalk) attached to one end. The attached part may be quite large, as in the case described by Hargitt (1912) and Weimer (1918), or merely a small stalk, as in some described by Curtis (1916). Eggs such as the one described by Chidester (1915), where the egg is bent but only slightly restricted in the middle, belong with this class.

Two explanations have been offered to account for the production of such eggs. Hargitt (1912) considered it possible that there had been a part of a yolk in the smaller part of the egg in addition to the normal yolk in the larger part. This would place such eggs with the series of double eggs and double-yolked eggs. Weimer found no evidence of yolk in one part of the egg he described and attributes its formation to the stimulus of hardened albumen. Chidester, on the other hand, attributes the shape of the egg he describes to a constriction in the oviduct and considers it possible that the same explanation applies to other similar cases. This constriction produces a partial separation of the yolk and albumen.

2. *Cases Obtained.* It is fairly obvious that there are two different types of eggs which resemble each other externally but are not necessarily the same or due to the same causes. Before discussing the causes which may produce such eggs, the results of experiments with artificial yolks may be briefly described.

No. 807. The abdomen was opened in the usual place (see above) and an egg found in the uterus which was palpated and the opening in the body wall closed with a cotton plug. The egg was laid within one hour. The next day a prune, with the stone removed, weighing 5.14 grams, was inserted through an incision at about the middle of the albumen part and the incision closed with catgut sutures. Eight and three quarters hours later an "egg" weighing 4.89 grams was found. The main part of this egg was 27.5 mm. long with, at one end, an elongated stalk 25 mm. long. The egg contained thick albumen which was hardened in parts. The albumen was pinkish in color with a few fibers from the prune present. A soft membrane covered the entire egg. No. 807 died the following day, when the prune was found where it had been placed, but its weight had doubled or increased to 9.95 grams.

No. 798. The results of the first operation on this hen have been described. The second operation was similar to the one on No. 807 but the material inserted consisted of a small paraffin sphere surrounded by a little sponge and covered with perforated rubber. This was recovered from the cage two days later without any egg membranes. Fifteen days after this second operation an egg similar in shape but larger than the one from No. 807 was obtained. The main part of the egg was 58 mm. long, with a stalk 68 mm. long. The distal part was enlarged and contained chalaza-like material and thick albumen. It was connected with the main part of the egg by a narrow neck. There was no yolk in this part. The main part was approximately normal in shape and contained a yolk weighing 14.74 grams and an elongated, hardened, piece of albumen attached in the middle to a little scar tissue. This piece, which weighed 0.91 grams, was located to one side and near the end of the egg where the stalk was attached. There was no chalaza in this part. A shell membrane, with a little shell weighing 1.42 grams, covered the entire egg. The egg weighed 35.50 grams or considerably less than other single-yolked eggs laid by this hen (table 9).

No further eggs were obtained from this hen until 18 days later when a normal egg was laid, except that it contained a small, flattened piece of hardened albumen in the fluid outer layer of albumen. The following day a "soft" shelled egg was obtained. This egg had a short, narrow stalk, open at one end and continuous with the main part of the egg at the other, just as if the enlarged part found on the previously laid egg had been torn off. The weights were: egg—45.31 grams; yolk—16.37 grams; shell—1.27 grams. The weight of the albumen, which contained no chalazal material, was, therefore, 27.67 grams. Only a few eggs were subsequently laid but they were, with the exception of one soft shelled egg, apparently normal in every way.

With regard to the abnormal shaped eggs here obtained, it appears fairly evident that these are not produced in the same way as most double eggs and some multiple yolked eggs. There is in this case no reason to believe that two separate stimuli started secretion and that the albumen so secreted was later joined within a common membrane. It appears more probable that the two eggs laid by No. 798 resulted from a displacement of a part of the albumen, which formed the stalk. In the first of these eggs it is certain that this displaced material included the chalazæ. Such a displacement might be due to a constriction of the oviduct, as suggested by Chidester,

or to unusual physiologic activity of the oviduct, particularly muscular activity. On this basis, eggs of this type are caused by an abnormal oviduct or an abnormally functioning oviduct. Eggs such as the one described by Chidester are due to similar causes except that here there is a change in shape of all the parts rather than a displacement of a portion of one part.

There are a number of points that have arisen in connection with the formation of the hen's egg, partly as a result of observations on abnormal eggs which may be briefly reviewed at this time.

It has been generally recognized that the oviduct must be in functional condition in order that secretion may take place. The assumption has apparently been made that the oviduct is continually in this state over a long period of time, corresponding to the length of litter. Apparent exceptions have, however, been noted by Tarchanoff (1884) and by Pearl and Curtis in a number of different papers. Such exceptions have occurred during the course of the present investigation in the case of artificial yolks placed in the oviduct. Furthermore, secretion has apparently stopped in the case of fistula hens with eggs in the uterus, although the eggs were not complete as to shell. These observations suggest that the different parts of the oviduct are not capable of continuous secretory activity and that there is a definite time relation to ovulation. The data at present are, however, too meagre to warrant drawing definite conclusions.

The absence of any mechanical stimulus in certain dwarf eggs has been referred to. The possibility that yolk had initiated secretion in such cases was not, however, excluded. It may be stated in this connection, that secretion was repeatedly observed in the oviducts of birds with fistulas although it is certain that no yolk had traversed the oviduct for a long period of time. In these cases, the oviduct was stimulated by the massaging required to keep the fistula open and possibly by foreign material which entered the oviduct through the fistulas. It, therefore, appears probable, even if not certain, that, as suggested by Pearl and Surface, a mechanical stimulus is required to initiate sufficient secretion to result in egg formation in the oviduct.

The fact has already been noted that an artificial yolk may pass through a presumably active oviduct without secretion taking place. Apparently these two activities of the oviduct may occur independently although they normally occur together. This probably indicates that the physiological factors, whether hormonal or otherwise, responsible for these reactions of the oviduct to a yolk or other mechanical stimulus, are different.

The writer is not aware of any published reports showing the effect of hormones on the muscular contractions of the hen's oviduct but such effects have been demonstrated for mammals (Reynolds, 1930, and others). In this connection it is of interest to note that Riddle (1921) was able to cause pigeons to lay prematurely, in some cases, by injections of pituitrin. He also states that anti-peristalsis was induced in some birds. The effect here is the expulsion of the egg, which may be caused by a number of substances and by fright. The results are, however, of interest because they indicate that the normal functioning of the oviducts of birds may be dependent on, or at least influenced by, hormones.

e. Summary

1. Dwarf eggs were obtained from two hens that were actively ovulating. One of these laid 7 such eggs, so spaced as to suggest that they resulted from normal ovulation, and an eighth which contained a vitelline membrane. The bird was killed after laying the last dwarf egg and yolk material found in the body cavity. This is interpreted to support earlier work from which it was concluded that such eggs generally follow the ovulation of yolks that subsequently escape into the body cavity intact, or after breaking.

2. Three double-yolked eggs were laid by a hen into whose oviduct an artificial yolk had previously been inserted. Operations of the type used have, in other cases, resulted in temporary or permanent inactivation of the oviduct, hence it is probable that lowered physiologic tone of the oviduct was the cause, although the rate of ovulation was obviously higher than at other times.

3. No double eggs occurred.

4. Three eggs with elongated stalks were obtained. One was a dwarf egg that resulted from the insertion of an artificial yolk. The other two had normal yolks but were laid by a hen that had been operated on twice and artificial yolks inserted, one of which had albumen and membrane secreted around it, while the other was expelled, without any egg envelopes, two days after it was inserted. It is considered probable that such eggs are due to a displacement of a part of the albumen, caused by constriction in the oviduct or unusual physiologic activity.

5. There are three processes or series of reactions that must take place, so far as the oviduct is concerned, before a normal egg can be completed. These are: (1) the growth and preparation of the oviduct for secretion, (2) the oviduct must secrete and (3) peristalsis or muscular activity must occur so that the yolk ,or other mechanical stimulus to secretion, is moved through the lumen of the duct. The last two normally occur together and follow the first, but variations in the functioning of the oviduct indicate that the secretory and muscular activities of the oviduct depend on different physiologic factors.

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L'AGRICULTURE AU JAPON

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I. Considérations générales

L'exploitation des richesses naturelles du sol a toujours été, dans tous les pays, la source même de leur prospérité ultérieure; cette prospérité s'est développée avec une rapidité plus ou moins grande, selon les circonstances particulières traversées par les différentes régions de notre globe au cours des âges, mais il est peu de pays qui nous aient offert, au début de ce siècle, le spectacle d'une agriculture aussi intensive et aussi minutieuse que l'est celle du Japon.

Aussi est-ce en grande partie à la faveur de ce degré de perfectionnement de l'agriculture que le développement économique de ce pays a pu prendre l'extension vertigineuse que nous lui connaissons. Si le Japon a pu, subitement à grande échelle, faire échange de richesses avec ses voisins et prendre place auprès des grandes puissances du monde, c'est parce qu'il y était préparé depuis fort longtemps; tous les moyens d'exploiter les richesses naturelles de l'Archipel étaient mis en oeuvre depuis de nombreux siècles; il ne suffisait que d'ouvrir de nouveaux ports au commerce extérieur pour stimuler la production et augmenter son débit, grâce aux contributions de la science occidentale.

Par quels dons particuliers le peuple japonais a-t-il pu réussir, malgré les longs siècles d'un passé obscur, à apparaître tout à coup à notre civilisation sous les traits d'un peuple d'agriculteurs et de pêcheurs par excellence? Comment nos contemporains des derniers confins de l'Asie peuvent-ils malgré leur isolement se mesurer aujourd'hui avec les agriculteurs des Pays Scandinaves, les premiers du monde? Sans diminuer, en aucune façon, les qualités de cette race dont le labeur et la ténacité font l'admiration universelle, il nous faut reconnaître que le Japon agricole s'est formé par nécessité, d'une part, puis à la faveur de circonstances particulièrement heureuses, d'autre part, le Japon économique n'étant qu'une conséquence du Japon agricole.

Une première considération ne manque pas de nous surprendre, tout d'abord; c'est la très faible étendue des terres arables par rapport à l'étendue totale du pays: 15% seulement, tandis qu'elle est de

73 %	en	Italie	60 %	en	Belgique
28 %	en	Espagne	68 %	en	Angleterre
65 %	au	Danemark	44 %	en	Allemagne
58 %	au	Portugal	41 %	en	France
38 %	en	Amérique	5 %	en	Russie soviétique
16 %	au	Canada	9 %	en	Suède.

A l'exception de quelques plaines relativement vastes, la majeure partie des terres cultivées se trouve concentrée dans des vallées, souvent très petites et communiquant difficilement les unes aves les autres.

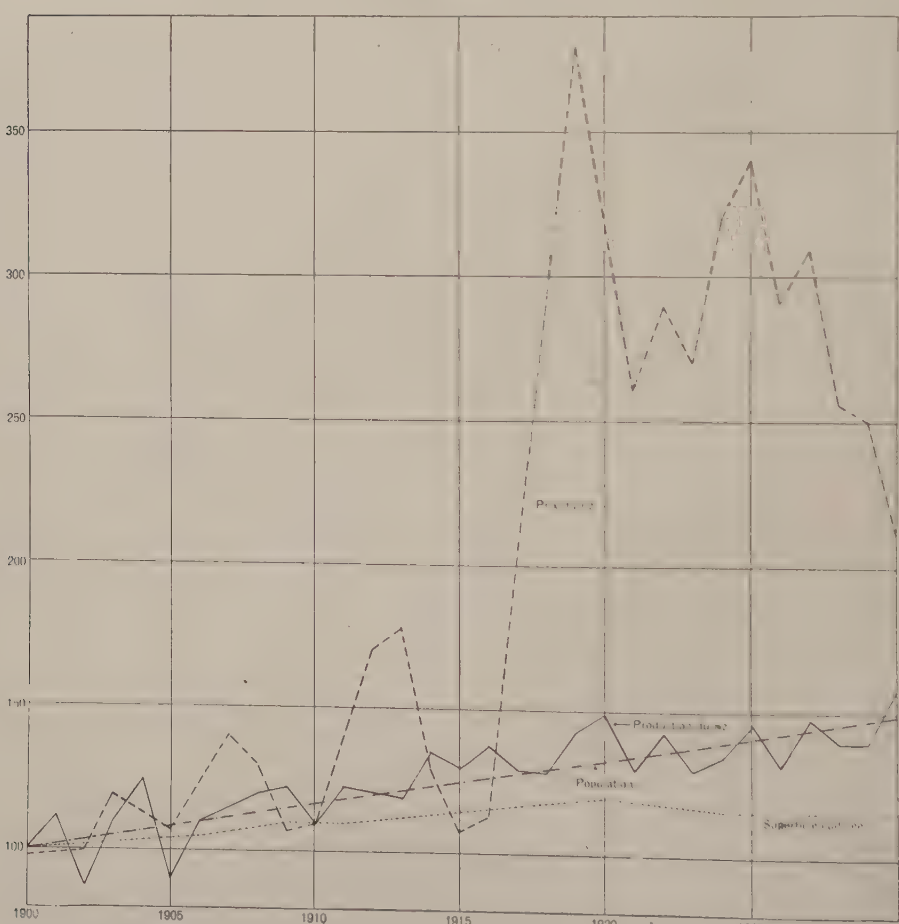
Si, d'autre part, nous rapprochons cette faible étendue des terres cultivées du chiffre de la population nous constatons que 100 hectares de terres cultivées doivent nourrir 950 habitants tandis qu'ils ne nourrissent que

300	habitants	en Italie	761	"	en Angleterre
135	"	en Espagne	309	"	en Allemagne
128	"	au Danemark	121	"	en France
79	"	en Amérique	33	"	au Canada
434	"	en Belgique	334	"	en Hollande

Telle est l'origine de l'intensité de l'agriculture nippone, intensité qui, pendant longtemps, a émerveillé les agriculteurs occidentaux.

Pour faire rendre le maximum à une terre généralement ingrate, le paysan japonais a dû se rendre maitre de tous les éléments que lui offrait la nature, et adapter à son profit toutes les particularités du reliéf et du climat.

GRAPHIQUE I.



Le chiffre de base 100 équivant à une production de riz de 41,466,000 kokus population de 44.825.590 hb. sup. cultivée de 5.400.000 cho. Prix du riz de yen 11.50 par koku.

De là, les moindres cours d'eau aussi savamment captés et multipliés, venant irriguer chaque pouce de terre arable que le paysan a dû disputer à la montagne; de là, les soins minutieux apportés à la fumure du sol et à la récolte. Une main d'oeuvre aussi abondante que laborieuse rend à la fois possible et nécessaire l'exécution de ces divers travaux: 55% de la population japonaise y est occupée, soit 10 personnes à l'hectare.

Si le paysan japonais a su tirer un tel parti de sa rizière, il n'a pu, par contre, élever de bétail sur les pentes abruptes de ses montagnes. Le sol granitique y est trop pauvre, trop sec; en outre, les conditions de végétation y eussent-elles été plus favorables qu'un préjugé religieux aurait entravé le développement de tout élevage. L'importance de l'élevage dans le passé était, d'ailleurs, tout à fait secondaire dans ce pays de pêche aussi facile qu'abondante.

Examinons à présent les circonstances à la faveur desquelles l'agriculture japonaise a pu se développer jusqu'en son état actuel. Quelques lignes tirées de l'histoire du vieil Empire vont nous les rappeler.

L'agriculture d'un pays a toujours été étroitement liée à son histoire politique; nous dirons même plus: elle en fait partie. La position géographique particulière de l'Archipel à la limite orientale extrême du continent asiatique a été éminemment favorable à la quiétude de l'Empire en le préservant dans une certaine mesure des convoitises de ses voisins; en outre, les côtes rocheuses présentent peu d'endroits propices aux débarquements et les moyens de défense ont pu être ainsi plus facilement concentrés aux endroits vulnérables. Enfin, le régime des vents, subissant des variations amples et rapides, rendait plus aléatoire encore le succès des manoeuvres des flotttes de l'époque. Quelques tentatives d'invasions chinoises ont échoué; l'histoire du Japon est d'ailleurs fertile en épisodes de ce genre auxquels l'imagination japonaise n'a pas manqué de mêler le fantastique et le mystère. Toujours est-il que le Japon n'a jamais connu ces grandes invasions qui ont saccagé l'Europe et l'Asie Continentale au début de notre ère, non plus que ces guerres interminables qui ont porté une atteinte si profonde à leur prospérité.

Sans doute, la paix n'a pas toujours régné dans le sein de l'Empire et les daïmios divisés furent, au contraire, en lutte perpétuelle; mais ces luttes et les combats sanglants qui en résultaient avaient davantage le caratère d'une suite ininterrompue d'escarmouches entre adversaires relativement peu nombreux que celui de véritables batailles organisées.

Enfin, et c'est là la caractéristique qui retiendra le plus notre attention au point de vue qui nous occupe: tandis que les belligérants occidentaux, munis d'un matériel de guerre lourd et encombrant, se rencontraient dans les plaines au préjudice des récoltes, les samouraïs, plus légèrement équipés, ont toujours préféré le labyrinthe de leurs montagnes pour théâtre de leurs exploits.

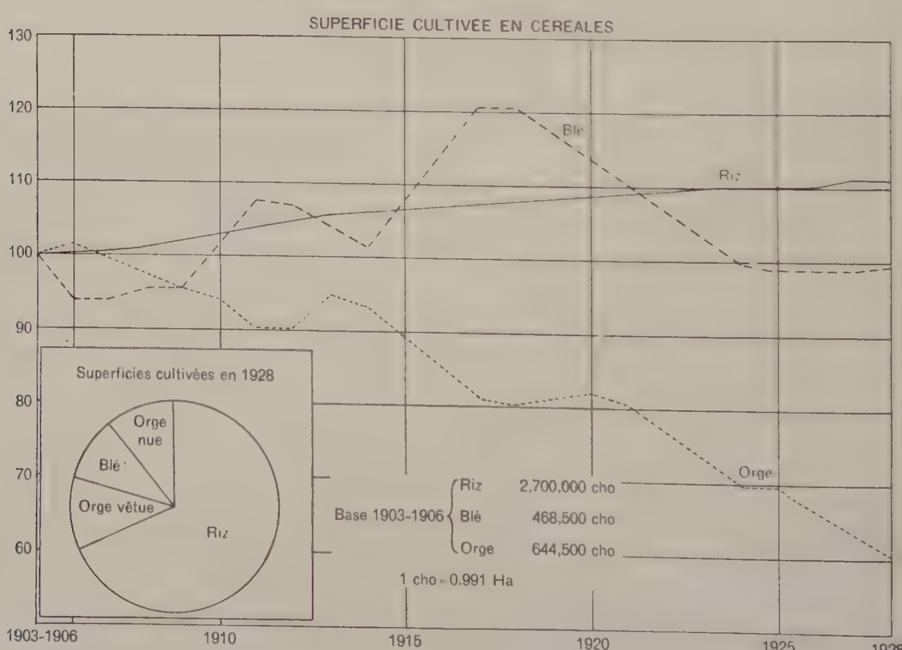
Si, ainsi que nous venons de le voir, l'agriculture japonaise a peu souffert des guerres intestines, elle a eu, par contre, davantage à craindre des éruptions volcaniques qui ont couvert de laves ou de cendres des étendues assez considérables; ces pluies de cendres, capables d'endommager les superficies cultivées, ne se sont d'ailleurs produites que rarement et restaient localisées au voisinage des volcans.

Le paysan japonais a donc pu cultiver sa rizière durant des siècles, à la fois protégé et exploité par un daimio désireux surtout d'accroître son domaine. Le paysan n'avait-il pas sa place avant les marchands dans la vieille hiérarchie japonaise et le daimio tout puissant ne conférait-il pas le titre de semi-samouraï et le droit de porter un sabre à ceux de ses paysans qui se distinguaient par l'abondance et la qualité de leurs récoltes? Dès le Moyen Age, des édits locaux réglementaient les étendues à consacrer au riz, ainsi que la façon de le cultiver; il en était de même pour la pêche et jusqu'à la forme des bateaux qui devaient rester incapables d'affronter la haute mer, afin que les pêcheurs ne pussent être tentés de changer de maître, en transportant ailleurs le produit de leur pêche. Toutes ces mesures devaient non seulement enrayer le danger des famines locales, toujours à craindre en raison d'un accroissement rapide de la population, mais encore assurer au maître de l'endroit une puissante milice.

De tous les facteurs que nous venons de passer rapidement en revue et qui ont fait du Japon agricole ce qu'il est aujourd'hui, l'accroissement de la population est certainement celui a le plus contribué à développer la production agricole.

Les documents officiels qui ont été publiés relativement aux chiffres de la population et des superficies cultivées ne nous permettent pas de remonter à plus d'une cinquantaine d'années en arrière, étant donné la grande difficulté d'établir des statistiques satisfaisantes avant 1900, époque à laquelle l'administration venait à peine d'être centralisée de façon effective. Nous nous bornerons, d'ailleurs à considérer ces chiffres comme étant de simples indications desquelles nous ne retiendrons que l'amplitude de leurs variations.

GRAPHIQUE II.



Le graphique I met en parallèle l'accroissement de la population, la variation de la superficie cultivée, ainsi que la variation de la production du riz, depuis l'année 1900 jusqu'à nos jours.*

Ces courbes montrent de façon particulièrement suggestive que la production du riz qui occupe 60% de la superficie cultivée, n'a cessé de croître en raison directe de l'accroissement de la population; l'on voit, en outre, que l'augmentation de la superficie cultivée a été moins rapide que celle des deux facteurs précédents. L'on déduit de ce fait une augmentation notable des rendements qui ne peut être attribuée qu'à l'amélioration des procédés de culture.

D'autre part, l'examen des graphiques II met en évidence l'importance relative des étendues consacrées aux céréales: l'étendue des rizières a toujours été en augmentation progressive à l'inverse de celle des autres céréales qui ont dû subir de nombreuses fluctuations. On en déduit également que, de toutes les céréales cultivées au cours de ces dernières années, c'est le riz qui, toutes proportions gardées, a le plus bénéficié de l'augmentation de la superficie cultivée.

Les récoltes de riz obtenues au cours des cinq dernières années ont été les suivantes (en kokus de 1.80 H1).

Année	1925	Ha.	3,153,830	Kokus	59,704,285
	1926		3,258,270		55,592,820
	1927		3,673,385		62,102,540
	1928		3,191,735		60,303,090
	1929		3,210,480		59,553,270
	1930		3,240,325		66,867,530

L'on voit que la récolte de 1930 fut particulièrement abondante, excédant de 7,300,000 kokus celle de 1929.

A ces quantités, doivent s'ajouter les récoltes obtenues en Corée et à Formose.

	Corée	Formose	
1925	14,773,000	6,443,000	Kokus de
1926	15,301,000	6,214,000	1.8 Hl
1927	17,299,000	6,899,000	
1928		6,700,000	
1929	13,701,700	6,480,700	
1930	19,250,000	7,540,000	

Cependant, malgré l'augmentation continue de la production du riz relativement aux besoins de la consommation, le Japon a dû importer les quantités suivantes de l'étranger:

* Les chiffres de production du Riz correspondent à l'ensemble du Paddy (culture irriguée) et du riz (culture sèche). La production du paddy étant en moyenne de 97.5% et celle du riz de 2.5% seulement de la production totale, le mot "Riz' designe principalement le paddy, aucune mention n'étant faite du riz de culture sèche en raison de sa très faible importance relative.

Il est à noter que ce rapport entre les productions de paddy et de riz est resté sensiblement constant depuis 1900, la production du paddy n'ayant jamais été inférieure à 97%, minimum atteint en 1930.

1925	5,136,000	Kokus de 1.8 Hl
1926	2,141,000	
1927	4,128,000	
1928	1,753,000	
1929	1,248,000	
1930	1,202,000	

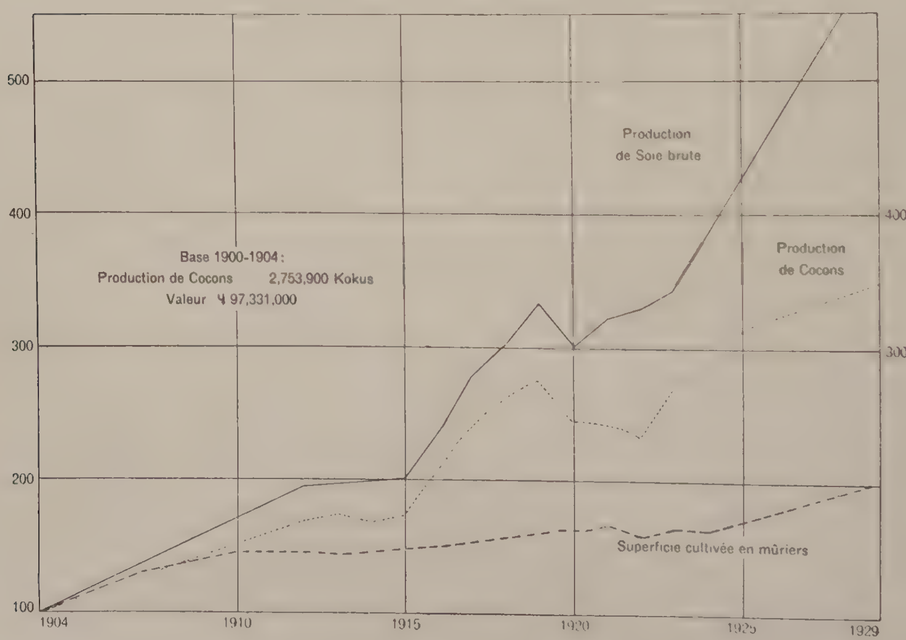
Tandis qu'il n'a exporté que des quantités comparativement insignifiantes :

1925	266,000
1926	47,000
1927	35,000
1928	38,000
1929	539,300
1930	380,000

Il est intéressant de noter que les distilleries utilisent 4,300,000 kokus environ de riz par an pour la fabrication du saké (alcool de riz) et que cette quantité excède de beaucoup les quantité importées.

La surface consacrée au blé s'est considérablement développée de 1915 à 1920, à la faveur de la guerre européenne, période pendant laquelle cette culture était particulièrement rémunératrice; dès 1924, cette superficie retombait au niveau de 1910, malgré les encouragements du gouvernement, désireux de diminuer ses importations du Canada, de l'Australie et de la Chine. Ces importations ont été de

GRAPHIQUE III.



1925	3,400,000 kokus
1926	5,155,000
1927	3,421,000
1928	4,821,000

En ce qui concerne l'orge, sa production n'a cessé de décroître depuis 1905 malgré le développement de l'industrie de la bière. Ce fait s'explique aisément, si l'on considère que pendant longtemps le paysan japonais ne s'est nourri que de produits de qualité inférieure, réservant les meilleurs, soit pour son seigneur, soit pour la vente; c'est ainsi que sa nourriture comportait une assez forte proportion d'orge mélangée au riz traditionnel. Or, tandis qu'au cours de ces dernières années, la production du riz augmentait et que son prix subissait de nombreuses fluctuations, le bénéfice réalisé par l'usage familial de l'orge diminuait de plus en plus; le sacrifice de son confort n'étant plus compensé par un bénéfice suffisant le paysan a diminué de plus en plus la quantité d'orge qui entrait dans sa ration quotidienne. Ce mouvement s'est encore accru par le fait du développement considérable acquis par l'industrie de la soie, nouvelle source de profit pour le cultivateur. Des surfaces occupées jusqu'alors par l'orge furent progressivement remplacées par des mûriers; ce remplacement était d'autant plus facile et rapide que cette plante rustique est relativement peu exigeante en principes nutritifs et s'accommode de sols même très pauvres.

Le Graphique III montre les variations subies par la culture du mûrier; superficie cultivée, production des cocons, production de la soie, prix de la soie brute.

Ces courbes montrent qu'à l'instar dece que nous avons constaté pour le riz, la quantité de cocons produits a augmenté beaucoup plus rapidement que l'étendue des surfaces cultivées en mûriers.

L'année 1929 marquera vraisemblablement un point culminant dans l'histoire de la culture du mûrier. Actuellement, la mévente des cocons est telle que le paysan a entrepris d'arracher une partie de ses mûriers au profit de sa rizière; cette réduction de la surface cultivée en mûriers est estimée à 20% environ. La diminution de la production qui en résultera en 1931, sera vraisemblablement d'un pourcentage supérieur si l'on tient compte du fait que les mûriers qui subsistent n'ont reçu qu'une fumure très réduite en 1930—sinon aucune—et que le sol se trouve, par conséquent, dans des conditions défavorables à un rendement normal.

Quoique développées sur une étendue becaucoup moins considérable, les cultures de pommes de terre et de soja sont à signaler. La pomme de terre entre de moins en moins dans l'alimentation du peuple japonais. C'est ainsi que la production qui était de 1,829,800 tonnes en 1919, est tombée à 936,400 tonnes en 1929. La production des pommes de terre douces qui était de 4,460,000 tonnes en 1919, est également tombée à 3,004,000 tonnes en 1929.

L'amélioration des rendements des principales cultures est représentée par les courbes IV. Nous avons déjà pu nous rendre compte précédemment que cette amélioration entrait pour une très grande part dans l'augmentation de la production agricole du Japon. En ce qui concerne le riz en particulier, nous voyons que, pour une superficie égale, la production moyenne a augmenté de 20% environ au cours des vingt dernières années. Pour le blé et l'orge, cette augmentation est encore plus marquée, puisqu'elle atteint 40%.

(à suivre)

CANADIAN SOCIETY OF TECHNICAL AGRICULTURISTS

Eleventh Annual Convention

The Eleventh Annual Convention of the C.S.T.A. has come and gone. Those of us who have been privileged to attend most of the Conventions, and especially the last four or five, have felt each year that the last was better than any which had preceded it, hence the Convention at the Ontario Agricultural College, Guelph, was looked forward to with pleasant anticipations and we believe that no one who attended it was disappointed. If it were merely numbers which made an annual convention then the Eleventh would lead on that score alone for the registration was about five hundred, being the largest in the history of the C.S.T.A. But although numbers give some indication of the success of a convention it is the satisfaction of those who attend which counts most of all and we can safely say that at no time in the history of the C.S.T.A. was there more general satisfaction than at this Convention.

The arrangements made by the Ontario General Committee and the various local Committees working with them were carried out with great smoothness and did much to make the Convention the great success it was.

There was a good programme of lectures and the special lecturers who came from other countries this year, through the kind co-operation of the Dominion Department of Agriculture, the Empire Marketing Board and the Ontario Agricultural College gave much food for thought in their addresses.

The weather was very favorable which also aided materially in making the Convention go off well.

The beds at the Ontario Agricultural College were comfortable, the food good, and the campus looking fine, the spacious new residence dominating the whole. Good fellowship abounded; old friendships were renewed and old college days reviewed.

Monday, June 22nd, was devoted to business of the Directors. There were general lectures Tuesday morning and part of the afternoon, and in the evening at Memorial Hall, O.A.C., the unveiling took place of the portrait of the late General Secretary, F. H. Grindley, painted by E. Wyly Grier. On the platform were past Presidents Howes and Sackville, and N. Savoie of Quebec represented past President Roy; there were also President Macoun and President-elect Arkell. The ceremony was simple. The President in a few words told of what had led up to the painting of the portrait. He was followed by N. Savoie and Dean E. A. Howes who both paid tribute to the late Fred Grindley. Dean Howes then unveiled the portrait and after a minute's silence with bowed heads the ceremony ended.

During the latter part of Tuesday afternoon and on Wednesday morning the Convention broke up into sections and there were meeting simultaneously the Horticultural Group; the Soils Group; the Canadian Society of Agricultural Economics: the Eastern Canada Society of Animal Production; and the Canadian Phytopathological Society.

The members and their wives were driven to Niagara Falls on Wednesday afternoon and on arrival at Queenstown Heights were given the opportunity of taking several alternative trips. They assembled at the Refectory, Victoria Park, at 7.00 p.m. to partake of the Banquet provided by the Ontario Government, at which about four hundred and twenty sat down. A very enjoyable evening was spent, which ended in watching the colored lights playing on Niagara Falls.

On Thursday morning the party motored to the Horticultural Experimental Station, Vineland, Ontario, seeing interesting places and projects en route, not the least being the new Welland Canal along which the route lay for some distance. After a tour had been made of the Experimental Station a delightful luncheon was served on the lawn by Director E. F. Palmer and his staff, following which an open lecture was given in the Community Hall. The party reached the Ontario Agricultural College without mishap in good time for the Ontario Agricultural College Banquet where there was assembled probably the largest body of technical agriculturists which ever met at one time in Canada. Speakers were Honourable T. L. Kennedy, Minister of Agriculture for Ontario; Honourable W. G. Martin, Minister of Public Welfare for Ontario; Dr. G. I. Christie, President of the O.A.C., who also acted as Chairman; and the President W. T. Macoun.

Following the Banquet a special entertainment was put on in the Memorial Hall by Al. Plunkett and his Company, which was very much appreciated, and the evening closed and the morning began with a very enjoyayble dance at Macdonald Institute.

Friday morning and part of the afternoon was devoted to business, there being the reports of the various standing committees which comprise some of the best work the Society is doing.

The Convention closed late Friday afternoon with a Meeting of the new Board of Directors.

The ladies were well looked after at this Convention and special arrangements were made for their entertainment and comfort, including a visit to Toronto, and, of course, the trip to Niagara Falls and Vineland.

The one regret at this Convention was the absence of the General Secretary, Mr. Howard L. Trueman, who on his way to the Convention met with a painful motor accident. Much sympathy was expressed for him. Fortunately, the accident was so near the time of the Convention that Mr. Trueman had his annual report, financial statement and other matters in good order and, while he was much missed, it was possible to get along.

Too much cannot be said of the fine work done by the Ontario General Committee, under the Chmairmanship of Mr. J. B. Fairbairn, Vice-Chairman Dr G. I. Christie and Secretary Mr. Stanley White, who also acter as Secretary during the Convention.

Associated with this General Committee were the Entertainment Committee, the Publicity Committee, the Transportation Committee, the Accommodation Committee and the Ladies Committee, for the work of whose members and especially the Chairmen, too much praise cannot be given.

CONCERNING THE C.S.T.A.

New Members

The following applications for regular membership has been received since May 1st, 1931:

Birk, L. A. (Toronto, 1931, B.S.A.), Guelph, Ont.

Brown, H. D. (Toronto, 1921, B.S.A.), Chatham, Ont.

Bunner, W. K. (Toronto, 1923, B.S.A.), Accra, Gold Coast.

Butler, A. N. L. (Toronto, 1930, B.S.A.), Guelph, Ont.

Cooper, T. B. (McGill, 1931, B.S.A.), Macdonald College, P. Q.

Cuthberston, J. A. (Toronto, 1921, B.S.A.), Fort William, Ont.

Davidson, W. A. (Toronto, 1928, B.S.A.), Perth, Ont.

Deacon, K. E. (Toronto, 1930, B.S.A.), Unionsville, Ont.

Grauer, F. W. (British Columbia, 1930, B.S.A.), Eburne, B. C.

Harrison, N. W. (Toronto, 1928, B.S.A.), Emo, Ont.

Hide, J. C. (Alberta, 1930, B.S.A.), Edmonton, Alta.

Keen, Eric (Alberta, 1931, B.S.A.), St. Paul, Minn., U.S.A.

Landry, J.-A. (Montreal, B.S.A.), Montreal, P.Q.

Lohse, H. W. (Denmark, 1925, B.S.A.), Macdonald College, P.Q.

MacKay, K. G. (Toronto, 1906, B.S.A.), Winnipeg, Man.

Millinchamp, R. (McGill, 1930, B.S.A.), Macdonald College, P.Q.

Painchaud, R. (Laval, 1923, B.S.A.), Montmagny, P.Q.

Potts, A. E. (Edinburgh, 1912, B.Sc.), Saskatoon, Sask.

Pritchett, E. G. D. (Toronto, 1930, B.S.A.), Ormesby, Yorkshire.

Rousseau, P. (Laval, 1929, B.S.A.), Trois Pistoles, P. Q.

Sweeney, J. R. (Toronto, 1920, B.S.A.), Winnipeg, Man.

Notes and News

E. R. Bewell (Manitoba '14) has been attending the University of British Columbia and has obtained his M.S.A. degree, specializing in Agricultural Economics.

C. G. O'Bee (Alberta '30) has changed his address to: c/o Union Milk Company, Calgary, Alta.

W. J. McLeod (Saskatchewan '23), formerly Agricultural Representative with the Saskatchewan Department of Agriculture at Govan, Sask., has been appointed Zone Manager for the Colonization Finance Corporation, Moosomin, Sask.

H. A. Derby (Toronto '23), formerly Instructor in Charge of Market Milk, Iowa State College, is now with the Dairy Corporation of Canada, 80 King Street West, Toronto, Ont

M. J. Champlin (South Dakota '09), Senior Professor of Field Husbandry at the University of Saskatchewan, who has for several months

been taking graduate work at the University of California, Berkeley, Cal., has resumed his duties at the University of Saskatchewan, Saskatoon, Sask.

J. H. Maduke (Saskatchewan '28) has changed his address to: 617, 21st Street West, Prince Albert, Sask.

J. Sydney Dash (McGill '13), Director of Agriculture, Georgetown, British Guiana, is in Canada on leave and is spending the summer months at Como, P. Q.

G. R. Lane (Toronto '24) who, for the past two years, has been Assistant to the Chief Forester and Forester in charge of Reforestation, for the Canada Power & Paper Corporation at Grand'mere, P.Q., has been appointed Chief of the Protective Service, Canadian Pacific Railways, Lucerne-in-Quebec, P.Q.

The following Student Members have advised their respective changes of address, as follows:

C. C. Strachan—from University of British Columbia to Dominion Experimental Station, Summerland, B.C.

Emile Boutin—from Ste. Anne de la Pocatière to Box 83, D'Israeli, Wolf County, P.Q.

W. J. Cowie—from University of Saskatchewan to 314 Albert Avenue, Saskatoon, Sask.

T. A. Leach—from University of British Columbia to 3594 King Edward Ave. West, Vancouver, B.C.

C.S.T.A. Employment Bureau

An assistant is required to handle garden vegetable and forage crop work. Candidates must be graduates of a Canadian agricultural college and have special knowledge of these subjects. Salary would be arranged commensurate with the amount of experience and previous training of applicant. Please give full history of experience and qualifications, and address reply to: Position No. 107 C.S.T.A. Employment Bureau, P.O. Box 625, Ottawa, Ont.